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# Developing and evaluating an embodied telepresence system for a real-world context

# Sam Nemeth

# PhD





**Developing and evaluating  
an embodied telepresence system  
for  
a real-world context**

PhD Thesis

Sam Nemeth

A thesis submitted in partial fulfilment  
of the requirements of the  
University of Northumbria at Newcastle  
for the degree of  
Doctor of Philosophy

September 2020

*Research undertaken in the  
Faculty of Arts, Design & Social Sciences*

## Abstract

This thesis is based on the field trial of a telepresence system. My ambition was to design in a user-centred, collaborative process, a system with simple, embodied control. Elementary in my approach was that the input of the end users extended to the implementation phase, where they could familiarize themselves with an application. A flexible design method allows continuous adaption of the system until the final deployment. I decided to call the design approach I applied in this study *conjoint control*.

In cooperation with experts in the field of telepresence and remote control of camera systems, whilst also drawing on the worldwide communities of open source programmers and maker culture, the system was built in several design cycles. I subsequently performed a field trial of the system when it was used in an office environment for six months.

Theoretically, the study is grounded in a number of concepts in the HCI field. One of the central ideas is calm technology, advocating a selective, calm approach in our interaction with computers. This study is furthermore inspired by the tangible user interfaces (TUI) concept, that proposes interaction with computers through the physical environment, rather than through screens, keyboards and mice. A more recent theoretical framework that influenced this study is somaesthetic interaction design, that involves our complete body in interaction with computers and advocates more tranquil interaction models with limited functionality.

The results of this study indicate that the design approach of conjoint control generates a good user experience and a high acceptance level. Furthermore, the collaborative design process and the extensive, playful, implementation phase had a positive effect on the validation of users of the system. I conclude in this thesis that conjoint control is a viable approach for the design of a specific area of interactive systems. Simple, physical interaction, based on a collaborative design process with experts and user groups, with a tight coupling to the functionality, could be embraced as a future direction for HCI.

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Cover drawing by Ine Poppe.

## Acknowledgements

Firstly, I would like to express my sincere gratitude to my supervisor Professor Lars Erik Holmquist, for the continuous support, for his patience, motivation, and immense knowledge. Professor Holmquist invested an enormous amount of time and energy in helping me with my study and I could not have imagined having had a better supervisor. I'm thankful to Doctor Ben Salem, my supervisor in my first year at Northumbria University, who facilitated this PhD in the first place. I would like to thank the rest of my supervision team: Professor Stephen Gibson and Professor Joyce Yee for their insightful comments and encouragement. I'm grateful to Doctor Ahmed Kharrufa of Newcastle University who provided me with invaluable input for this thesis. I thank Rob Linders of Artivisuals in Amsterdam who generously helped me in numerous ways in the hardware and software development of the telepresence receptionist. I'm very grateful to Graham Smith at University College Dublin for his support in the explorative phase of my PhD and Jeff Mann for the technical advice. My fellow PhD student Simon Scott-Harden: I thank you and your parents for facilitating our writing sessions at Greystoke and in Newcastle. Professor Abigail Durrant, Professor Gilbert Cockton, Professor Mark Blythe and Professor John Vines: your advice and support was greatly appreciated. I also thank the Co-Create group who adopted me in their community and provided me with a warm, knowledgeable and critical context. I thank my colleagues, the PGR students at the Glenamara Centre at Northumbria University. The staff at the PROTO Centre for Emergent Technologies in Gateshead have been a great help: Lesley Goldsworthy, Raegan Hague, Luke Edmundson, Robert Garrod and Mathew Hall. I must also mention Chris Pape and Alex Cook of the PROTO centre, who supported me with their trust and patience. For last minute advice and support I thank Alistair MacDonald of FabLab Sunderland. I'm very grateful to all the other people and communities, too many to name them individually, that participated in my studies as test persons during the design process as well as in the field trial. I'm more grateful than I can ever express in words to my superb wife Ine Poppe. She is the love of my life and without her, none of this would have been possible. I thank my son Zoro, his wife Veerle and my grandchildren Kozmo and Zirkon for their overwhelming love. My brother Harmen and my cousins, uncles and aunts, my wife's family, Martin, Patty, Mauro and Fabio, Cora and Aenea, and my dearest mother in law Hennie: you kept inundating me with your support and love, I'm deeply thankful to all of you.

## **Declaration**

I declare that the work contained in this thesis has not been submitted for any other award and that it is all my own work. I also confirm that this work fully acknowledges opinions, ideas and contributions from the work of others. Any ethical clearance for the research presented in this thesis has been approved.

I declare that the word count of this thesis is 48116

Name:

Signature:

Date:

# 1. Introduction

## **Introduction: motivation**

This thesis is the account of a practice-led PhD: I designed and built a telepresence application with a simple physical controller to perform a field trial in an office context. To provide an insight in the motivations and the objectives of this study, I start this chapter with a brief overview of the complete project, beginning with my personal history with HCI and why I studied this particular subject from this perspective.

I studied at the University of Amsterdam, the Netherlands, where in the 1980s the typewriter was still the most commonly used writing technology. However, when I graduated, in the early 1990s, most university employees used a computer. For me, a product of the world of typewriters, paper and ink, it was too late for a smooth transition to computers. It took me a while to adapt to the way of thinking required for a computer interface, like the MS Dos operating system (see section 2.1.1). Despite these initial difficulties, I persisted and further explored the digital world.

The introduction of the graphical user interface (GUI) made my dealings with computers easier and therefore maybe also more pleasant. The display with icons, pointer and the metaphorical connections with the real world not only allowed me to use more complicated software but also to enjoy it: the aesthetics of GUIs appealed to me. The down side: that I was staring at my screen for long periods of time, neglecting many of my senses and capabilities, I took for granted.

I did not even imagine designers could devise alternatives for the graphical user interface. That might be the reason the CHI paper of 1997, *Tangible Bits: Towards Seamless Interfaces between People, Bits and Atoms* of Ishii and Ullmer<sup>1</sup>, had such an impact. The central concept, the idea that computer

interfaces could be designed as an integral part of the world around us, was an eye-opener for me and for many of my generation. But I also interpreted the paper as a call for a more inclusive, intuitive, human-computer interaction. The implicit message of *Tangible Bits* was that, from my perspective, the users of digital technology themselves had a role in designing and building innovative ways of human-computer interaction.

In 2016 though, when I started this study, the impact of TUI research on the design of real-world products seemed to be limited. Human computer interaction was still dominated by mice and touch screens and commercially available TUI were rare. So I wondered: why had this promising concept that inspired me and ignited so many studies and related projects, not delivered more results for everyday practical functionalities? Could a different scope on tangible interaction be a solution for applications that are still mostly controlled by GUI? To be more precise: can a simple, collaboratively designed, physical interface be an improvement of the control of specific real-world applications in specific contexts for everyday users?

The other concept that is manifestly present in this study is telepresence, or remote collaboration, the combination of technologies that allows users to feel present and perform tasks at another location. The idea was first presented in the 1980s, but in fact popularized in the beginning of this century when applications like Skype and telepresence robots were introduced. Although the use was steadily growing, these technologies did not revolutionize the practice of telecommunication, until this year, 2020, when I started correcting this thesis, and the Covid-19 pandemic took the world by surprise. From March 2020 onwards, conference calls became standard practice for private use and a tool to facilitate professional collaboration for many organizations.

To explore the question whether or not simple interaction models for a limited functionality could be a worthwhile addition to the HCI toolkit, I designed and built the object of this study, the telepresence receptionist. The system combines these two concepts: a telepresence system for a reception desk, with simple, bespoke interaction that is intuitive and with a direct connection between in and output. It was designed in cooperation with users and experts and I subsequently performed a field trial. The ideation, design process,

implementation, in situ use and finally the field trial of the telepresence receptionist system, are described in this thesis.

## 1.1 Inspiration

Apart from the Tangible User Interfaces paradigm mentioned above, there are a number of concepts that have inspired this study. Two of the more relevant approaches in HCI that influenced the ideation and design process are ubiquitous computing<sup>32</sup> and calm technology<sup>35</sup>, that were proposed by Mark Weiser in respectively 1988 and 1995. Ubiquitous computing, or 'ubicom' is the idea that computer functionality will eventually be everywhere, and as a result of this process will disappear from sight, although they are implemented in many objects that surround us. The concept of calm technology is the ideological counterpart of ubicom: advocating a slower, more intuitive interaction model drawing also on the peripheral senses of the user.

This correlates with the more recent concept of somaesthetic design, proposed by Kristina Höök<sup>77</sup> (section 2.5.2), that stresses the importance of the bodily experience in design and how designers can develop somaesthetic sensibilities. Another point Höök makes is that users should not be overloaded with choices but are entitled to a more gentle dialogue with the applications that surround them. The idea that instead of the platform model where one device performs many tasks but not all of them very well, a single device can be designed that performs one task in an outstanding way, is one of the other cornerstones of my study.

An inspiration is furthermore the current development of affordable prototyping tools with the ongoing evolution of platforms for electronics like Arduino<sup>2</sup> and Raspberry Pi<sup>3</sup> but also 3D printers. There is a worldwide community of tinkerers, the thriving *maker culture*<sup>4</sup>, that opens up the use of these technologies for larger groups of people<sup>5</sup>. These developments might pave the way for a more sophisticated and cheaper HCI development cycle<sup>6</sup>. My work relates to the tinkering, DIY approach of HCI exploration that the use of these technologies facilitates<sup>7</sup>.



## 1.2 Conjoint control

This study would not have been what it is without the TUI paradigm. Nevertheless, I would argue it is influenced rather by the spirit of the early TUI publications than by the letter of the entire body of work of TUI research. The application I built for this study would not be considered a 'real' TUI by many in the field. Yet, it has features of a TUI: direct manipulation, materiality and a form of embodiment, qualities that are inherently present in the tangible interfaces paradigm.

Because the design approach of the telepresence receptionist differs fundamentally from the TUI paradigm, I introduce a new term: conjoint control. One of the more important distinctions is that it incorporates the design and implementation process in its concept. Apart from the idea that the functionality of a system is controlled by a bespoke, physical interface with a very tight coupling between the in- and the output, one of the basic features of the approach of conjoint control is that the interaction is designed in a collaborative process with users and experts. The last adjustments are proposed by the end user, who is asked to engage in a relatively extensive implementation process, where last minute adjustments to the system can be made. Furthermore, conjoint control ideally has a limited, well defined task: it is designed for a restricted amount of functionalities.

The domains in which I argue conjoint control is appropriate are for instance those with a direct form of specific interaction like the remote control of camera systems, cranes, robotics or remote collaboration applications. User groups that could benefit from this form of control are for instance inexperienced or challenged users that are working with systems with a defined functionality. But also experienced users, having to control systems on a daily basis that otherwise would require a lot of time-consuming mouse clicking, or manipulating a joystick, can benefit from the conjoint control approach.

The approach of conjoint control is basically, among a number of other concepts and ideas (see chapter 2), influenced by the work of Donald Norman, especially where affordances and simplicity, the self-explanatory, relationship between the manipulation of the interface and the control of a system, are concerned. In particular, Donald Normans book *The Design of Everyday Things*<sup>8</sup> provided me with the foundations for the design of simple

controls: buttons, sliders and switches. Here he argues, among many other things, that a strict application of constraints and affordances, the inherent limitations and opportunities of a design, help the user in the intuitive control of a system. These concepts are elementary to this study.

### **1.3 Telepresence / remote collaboration**

Telepresence, the concept of using technology to perform tasks over distances, was introduced by Marvin Minsky<sup>9</sup> in 1980 and encompasses a broad spectrum of applications, from systems that provide feedback through robotics or other stimuli to videoconferencing. Telepresence historically has its overlaps with the TUI paradigm<sup>10</sup>. Applications using for instance haptic feedback to communicate empathy over distances, sometimes in the centre of attention, sometimes in the periphery, have been part of telepresence studies since the 1980s but have also been subject of TUI projects at MIT and elsewhere (ibid.).

There is ongoing development in tools for 'remote collaboration', a term closely related to and overlapping with telepresence, also originating from the last century, that is currently frequently used for tools for cooperation over the internet. The use of telepresence robots: remote controlled moving screens with camera and microphone, that are able to for instance participate in conferences, has been steadily growing. Also teleconferencing, over increasing faster networks, has become more common in the last decade. As mentioned, the Covid-19 crisis was the wake-up call that made many companies, organizations and individuals aware of the possibilities of remote collaboration.

It is still unclear at the time of writing what the repercussions of the Covid-19 crisis for the use of these technologies will be. But there are indications<sup>11</sup> that telepresence, or remote collaboration, will continue to play a large role in professional and private communication, because of the obvious advantages for social distancing, sustainability, and its cost-effectiveness. On the other hand, now the various remote collaboration tools are more frequently used by many user groups, the shortcomings of these tools also become apparent, like the lack of emotional exchange and informal communication<sup>12</sup>. This opens up urgent new research and design opportunities in the near future.

#### 1.4 The telepresence receptionist

My objective was to design and build a system for a specific task, ideally to be used regularly by a defined set of users. Because I was familiar with the technology and its practical applications, I chose to focus on the control of remotely operated cameras. The interfaces of remotely controlled cameras can have numerous options, from the control of the diaphragm to adjusting the colours of the image. I zeroed in on the control of the movement, the panning and tilting (turning the camera and moving it up and down), and the zoom function (PTZ) of a remote controlled camera. These functionalities are generic and can be found in many applications, from security cameras to monitoring agriculture<sup>13</sup>.

The advantage of the videoconferencing context for my PTZ explorations is that videoconferencing applications have the opportunity to be implemented in a real-world environment. In the first phase, I designed and evaluated a controller that operated a robotic telepresence screen, a video monitor equipped with a camera and microphone that shows the operator. Then I looked for an opportunity to design, build, implement and study a working telepresence application with a very direct and simple interface.

For the PROTO Emerging Technology Centre in Gateshead, UK, responding



**Figure 1: Telepresence screen (left) at the visitors end plus connected hotel bell.**

to a design question from the management, I proposed to design a telepresence system for the reception area. This system, a telepresence receptionist, welcomes the visitors to the centre by means of a telepresence screen, operated from another location by a 'real' receptionist.



**Figure 2: The telepresence receptionist: left the visitors end and right the operators end.**

A design cycle, using the feedback of experienced and less experienced users, resulted in a working prototype. The system consists of a telepresence screen in portrait mode with a connected physical hotel bell for the visitors end, and a smaller monitor, also in portrait mode, plus a controller, for the operator at the other location. It was installed in the PROTO reception area and on the reception desk of an adjoining building. Visitors arriving at the reception desk at PROTO, equipped with the telepresence screen where the 'real' receptionist was absent, were advised to ring the connected hotel bell (see Fig. 1) via a graphical display on the screen. The bell rings at the operator's end, in the other building, to inform the operator there is a visitor. The operator can then open the audio / video link, turn the remote screen and camera towards the visitor by means of the controller and communicate with the guest (see Fig. 2).

#### **1.4.1 Field trial**

The team managing the building used the system for six months, when understaffed or at moments when it was not too busy, like early in the morning or late in the afternoon. They were allowed a relatively long period to get used to the system, during what I call a 'soft implementation' phase, before they started using the telepresence receptionist in their daily practice. They participated in workshops and were also stimulated to 'play' with the telepresence receptionist when it was set up in a room close to the reception desk. After three months of use of the physical controller, the user group was asked to use a generic interface for the application: a joystick, for two months. The users were subsequently interviewed about the use of both types of controller.

The user group filled in a questionnaire at the end of the evaluation period. During the field trial, the team was also encouraged to comment on the use of the system. Furthermore I documented the trial with a brief ethnography and used this for the evaluation. At the end of the six months period I performed a qualitative study of the system, at the PROTO centre, with a group of 12 users without any experience. They were asked to alternately use both interfaces and perform a number of simple tasks with the system. This group filled in the same questionnaire as the group of 5 experienced users.

## **1.5 Ethics**

Field trials and collaborative design processes have their challenges where ethics are concerned. The system for instance involves cameras aimed at the entrance of an office (from the inside, no cameras aimed at the exterior) and the user group themselves can have privacy issues with the use of the system, as they are visible on a screen in a remote location.

Another obvious issue is whether or not an application as such that allows a receptionist to communicate over a distance, from a societal viewpoint is desirable. What are the advantages and disadvantages for employment, the security of the operator and visitor and for social interaction? I elaborate on this topic in section 4.6.

## **1.6 Research question**

The principal question during the design process and the field trial of the system was:

“Does the interface with tangible properties, for this well-defined and relatively simple task, provide an intuitive, positive experience for long term, experienced users?”

It proved to be a challenge to couple a sterile scientific research question that is thought out in advance with a generally quite messy, design process. To keep the study organized towards the ambition: to generate a rich variety of insights about design approach and the use of the telepresence system and its control, the research question was divided in a number of sub questions:

- How does the collaborative design process and the long implementation phase influence the experience of the system?
- What is the added value of the one-on-one interaction, the absolute control, to the experience of the system?
- How do users appreciate the limited array of tasks of the system?
- In what way is the approach I took: the user-centred, collaborative process to design a simple system where users could provide feedback until the implementation phase, an appropriate model for further explorations?

Overall, there was a focus on the dynamics of the design process itself: how to manage it and assess the trade-off between the feedback of users and experts and the design ambition. This was not always a self-explanatory process. An ambition was to maintain an open attitude towards all input and avoid cherry picking in the array of feedback. During the process, it transpired that controllers are different 'animals' from generic interfaces (like for instance a Graphical User Interface -GUI) and should be treated accordingly. In general, obviously users have more experience with GUI based interfaces or joysticks than with a bespoke, novel controller. This implies that the learning curve of applications with conjoint interaction is different, steeper and longer, from that of applications based on a generic interface model. For this reason I decided that the system be introduced to the users slowly. This extended period where the system was tried by the users, also provides the opportunity to give more thorough feedback.

Furthermore the user experience of the direct control of the system was assessed. This model, where the controller at all times shows the status of the system, was one of the elementary parts of the study. The limited functionality of the system is also a fundamental in the approach of conjoint control and I assessed whether or not this is validated and appreciated by the long term users.

The last sub question can be seen as an assessment of the overall approach of the process by its long term users: is the entire process, the design cycles, the implementation and the use in the reality of the reception desk appropriate, is this an approach that should be explored further?

Long term field studies<sup>14</sup> are a valuable addition to more limited, short term studies in HCI. But on-site studies are time-consuming, and have their issues, also because a researcher interferes with the day-to-day working process. Furthermore, and less obvious, a user study can influence a design process negatively if done 'by rule', rather than 'by thought' as Greenberg et al. argue<sup>15</sup>. This might be the reason that they are relatively rare. That seems unfortunate because, from my perspective, the litmus test in HCI is the everyday practice, the actual use of systems. Real-world studies have the potential to reveal user data that are otherwise easy to overlook, especially for alternative interaction models, with multifaceted user dynamics that are hard to assess in a relatively short period of time. Nevertheless, long term studies in real-world contexts are not by any standards a panacea for all interface design processes and evaluations. In chapter 8 the answer to the research question is formulated. The preceding chapters, where the design process and field trial are described, provide the foundations.

To give a context for this study, I discuss preceding computer interaction models and concepts followed by a chapter on the related concept of telepresence, or remote collaboration.

## **2. Literature review: computer interfaces, from command line to embodiment**

### **Introduction**

The study of the telepresence receptionist and conjoint control stands on the shoulders of a number of concepts, ideas and 'paradigms' in HCI. Obviously, the TUI paradigm is one of those, but as mentioned in chapter 1, also some of the preceding approaches in Human Computer Interaction (HCI), like for instance ubiquitous computing. To provide an understanding of the theoretical framework of this study, I will begin this chapter with a concise history of computers and the development of computer interfaces: from command line to the TUI paradigm. Also in this chapter I describe the development of TUI categorizations, whether or not they are called taxonomies, frameworks or something else. I will analyze what their unique properties and overlaps are, and what their meaning is in the context of my study and for the concept of conjoint control.

Section 2.5 is reserved for related concepts that influenced this study: slow technology and somaesthetic design, where the role of the body and simplicity is emphasized in relation to our experience of computer systems. Following this, there is a section on the study of controllers. Controllers, the more straightforward form of interfacing, are widely used, from games to cranes in ports<sup>8</sup>.

The last section is reserved for the concept of embodiment. In almost all frameworks that describe tangible interaction but also in telepresence, embodiment plays a central role. I will assess its meaning in these concepts and how it relates to this study.



## **2.1 Early computers and their interaction, from command-line to WIMP**

The history of computers<sup>16</sup>, and our interaction with them, is not a straightforward narrative but a map with several main roads and side paths. There were relatively slow periods and moments when the development of computers took a sprint. Progress towards the concept of a central computational machine that is able to perform different tasks, was made before, during and just after the Second World War<sup>17</sup>. The military research labs in the 1940s were well funded, well equipped and produced results of specific, practical use. But at the time, computational machines were still exclusively designed for specialists and the interaction models were designed accordingly. The idea that the computer could be a widely used multipurpose tool was developed 20 years later, at the end of the 1960s.

### **2.1.1 Command line input systems**

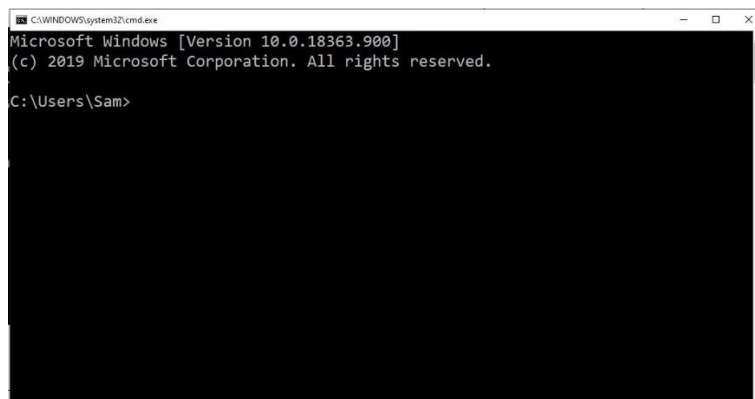
From the 19<sup>th</sup> century onwards, complicated industrial machines<sup>18</sup>, and later rudimentary computers<sup>19</sup> were programmed by means of punch cards: cards with holes. These cards were processed by machines that for instance could weave textile in patterns instructed by the code on the cards (see Fig. 3). The progress made around the Second World War and later, with the proliferation of computer screens, opened the way for the command-line input system<sup>20</sup>. This development can be seen as the 'dawn of human computer interaction (HCI)': the computational machines that had been the domain of specialists were made accessible to a larger group of users, enabling them to perform tasks without too much knowledge of the inner workings of the machines.



**Figure 3: Card punch machine.**

The command-line input system requires the user to type in commands, specific texts, by means of a keyboard. The computer responds according to the commands. A variety of command-line input operating systems for computers was developed from 1970 onwards, with Open VMS, UNIX and CP/M<sup>16</sup> as proprietary examples.

A frequently used command-line operating system was initially called QDOS (Quick and Dirty Operating System), later adapted for the personal computer and called PC-DOS, produced by IBM, or MS-DOS produced by Microsoft. This was the system that was installed on the generic personal computer well into the 1980s. The main advantage of the command-line model is that it is relatively light, meaning the system does not consume a lot of computing power and storage capacity. The command-line system (see Fig. 4) though, has a steep learning curve: for every application the user has to memorize, or keep looking up, a new set of commands.



**Figure 4: Command line interface on a recent Windows operating system.**

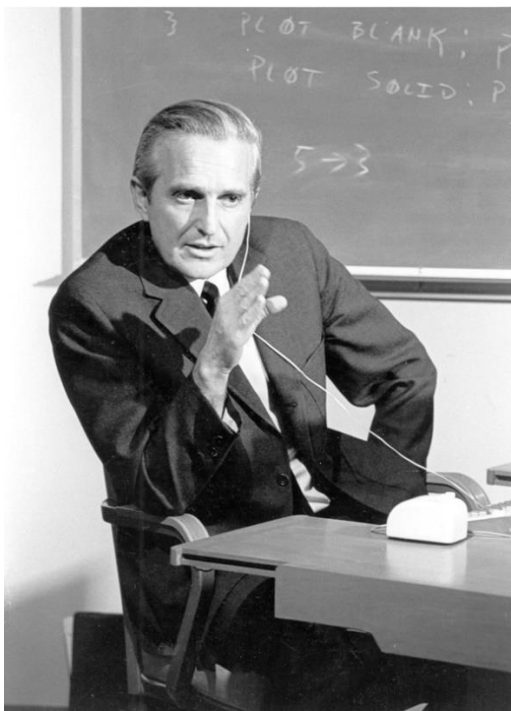
### 2.1.2 The WIMP interface model

The introduction of the WIMP (Windows Icons Menus Pointer) interface model was an important step towards the computer becoming a generic appliance in offices and later, also in homes. The quality of this system, using metaphorical icons on a screen that can be selected by a pointer, activated with a mouse click, is hard to overestimate<sup>21</sup>. That said, programmers still use command-line systems and there is a command-line function parallel to the WIMP on almost every computer (see Fig. 4). Nevertheless it is safe to argue that the WIMP system is still commonly used, as well as other systems, the most successful

one being the multi-touch screen, popularized in 2007 as the input system of Apple's first smartphone, the iPhone<sup>22</sup>.

The institute that conceptualized the first WIMP interface was the SRI, the Stanford Research Institute, that employed Doug Engelbart, a developer and researcher, who lead a team with the task to design a 'framework' with the new computer technology that could 'augment human intellect'<sup>23</sup>.

For the Association for Computing Machinery / Institute of Electrical and Electronics Engineers (ACM / IEEE) at the Computer Society's Fall Joint Computer Conference in San Francisco, Douglas Engelbart on December 9, 1968, with his team, showcased at what later became known as the *Mother of all Demos*<sup>24</sup> (see Fig. 5) the oN-Line System, or the NLS, a combination of hard- and software, featuring many of the concepts of modern day computer interaction.



**Figure 5: Douglas Engelbart at the Mother of all Demos.**

Engelbart demonstrated a coherent system with a screen, icons, pointer, mouse and keyboard and a system to organize data. His ambition was to indeed augment and improve office work<sup>23</sup>. According to digital journalism pioneer Howard Rheingold<sup>25</sup>:

“ the point he wanted to make had to do with changes in the overall system -- the capabilities such an artefact would open up for thinking in a more effective, wider-ranging, more articulate, quicker, better-

formatted manner. That is why he distinguished his proposed new category of computer applications by using the term augmentation rather than the more widespread word automation.”

Engelbart and co-workers, as apparent from his report for the SRI in 1962<sup>26</sup>, worked on a complete, homogenous system, rather than a chain of separate solutions<sup>27</sup>.

At the Palo Alto Research Centre of the Xerox company (PARC)<sup>28</sup>, in the 1970s, the concepts presented at the *Mother of all Demos* were further refined. In fact, they revolutionized the way humans interact with computers:

“The scientists of PARC changed all that. They took it as their credo that the computer must serve the user rather than the other way around. That it must be easy and intuitive to operate. That it must communicate with the user in human terms and on a human scale, even if at supernatural speeds. They were determined to tame the machine just as their ancestors tamed the wild dog and taught him to hunt and stand guard.” (ibid.)

The Xerox company at the time seemed indifferent to the results of its research lab, and failed to exploit concepts that later would generate billions<sup>29</sup>. Nevertheless PARC was instrumental in the development of the GUI and its related technologies. Competing companies like Apple, Microsoft and IBM benefitted greatly from their research.

The WIMP system became the common interface in the 1980s (see Fig. 6). In 1984, the first commercially available computer with WIMP interface, standard equipped with a mouse, the Macintosh 128K, was introduced by Apple. Soon Microsoft launched the Windows operating system and eventually with the Windows95 update produced a solid competitor for the Mac OS.<sup>30</sup>



**Figure 6: Standard WIMP office computer setup.**

## 2.2 The WIMP paradigm questioned

By the beginning of the 1990s, almost all personal computers were delivered with a WIMP interface<sup>31</sup>. At the same time, the disadvantages of this interface model became more and more clear. The most important issue being it neglected the sense of touch. It also became apparent that the dominant position of computer screens, forcing users to sit behind a desk for longer periods of time, could be a health hazard. This resulted in new concepts that challenged WIMP (see Fig. 7).

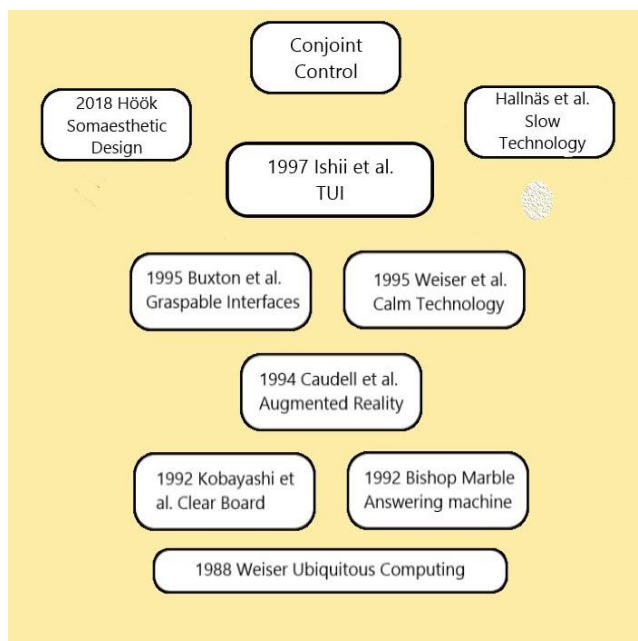
### 2.2.1 Ubiquitous computing

An alternative approach to HCI was formulated by Mark Weiser, chief scientist at PARC, in 1991. In *The Computer for the 21st Century*<sup>32</sup>, Weiser questions the importance of the personal computer. He argues the personal computer concept is merely a 'transitional step' to a more intuitive, advanced interaction system:

"a "personal" computer itself is misplaced, and that the vision of laptop machines, Dynabooks and "knowledge navigators" is only a transitional step toward achieving the real potential of information technology."

Weiser's answer to achieve this potential was ubiquitous computing (UbiComp), the third wave in computing (ibid.):

"Ubiquitous computing names the third wave in computing, just now beginning. First were mainframes, each shared by lots of people. Now



**Figure 7: Alternative HCI concepts.**

we are in the personal computing era, person and machine staring uneasily at each other across the desktop. Next comes ubiquitous computing, or the age of calm technology, when technology recedes into the background of our lives."

He describes the concept quite literally as 'things' (versus 'concepts') that are generally part of our everyday environment that could be enhanced, provided with added digital meaning and functionality. In that sense, this idea can also be read as an ideological statement. Weiser not so much wanted computers to be anywhere, but rather to be nowhere:

"The most profound technologies are those that disappear. They weave themselves into the fabric of everyday life, until they are indistinguishable from it." (ibid.)

Weiser argues that humans are programmed to have tactile feedback when interacting with the world. Following this, he did not see virtual reality - one of the emerging technologies at the time - as a fundamental interaction model: "Virtual Reality is only a map, not a territory." (ibid.) In *Some computer science issues in ubiquitous computing*<sup>33</sup>, in 1993, after first acknowledging virtual reality has its appropriate use contexts, especially in 'scientific visualization and entertainment', he clarifies:

"But as a tool for productively changing everyone's relationship to computation, it has two crucial flaws: first, at the present time, and probably for decades, it cannot produce a simulation of significant verisimilitude at reasonable cost (today, at any cost). This means that users will not be fooled and the computer will not be out of the way. Second, and most important, it has the goal of fooling the user--of leaving the everyday physical world behind. This is at odds with the goal of better integrating the computer into human activities, since humans are of and in the everyday world."

Ubicomp suggests technology should have a closer relationship with the world around us: users become so familiar with technology, they stop being aware of its presence. Weiser argues:

"Such a disappearance is a fundamental consequence not of technology but of human psychology. Whenever people learn something sufficiently well, they cease to be aware of it."

In other words, once users are able to use applications intuitively, technology is pushed to the background and users can focus on matters that are important: the world we live in, instead of screens, mice and keyboards.

A contemporary parallel to Ubicomp is the Internet of things (IoT), where technology is implemented in all kinds of 'things', connecting them to add functionality, like the connected fridge telling the user when products are over the 'best before date' or the bicycle that lets the rental company know where it is. IoT is actually introduced to the market, and with the aim to make our environment smarter by collecting data about for instance mobility, air quality or weather. Interestingly, Weiser et al. predicted correctly, in relation to ubicomp and also relevant for IoT, the debate about the security issues these technologies potentially cause. He and his team estimated that cryptography would have an important role in protecting the privacy of users from "over-zealous government officials"<sup>32</sup>. IoT at the moment is part of a similar debate involving privacy, safety and ethical issues<sup>34</sup>.

It can be argued that some elements of ubiquitous computing have become reality, at least where technology is concerned. We do live in a world now where most people own a smartphone: a powerful, *portable*, to stay in the terms of the 1990s, computer. There is also an ongoing tendency to equip products with RFID, transponders, small radio beacons that are able to store and send dynamic data, like location, speed or temperature. The availability of affordable microelectronics and the introduction of mobile data networks that are faster and able to provide more capacity, like the 5<sup>th</sup> generation mobile data network (5G), are potential opportunities for contemporary ubiquitous computing.

On the other hand, the ideology of Ubicomp, where a calmer, less demanding interaction with computers is advocated is to this date not realized. Screens are still a dominant form of feedback in computer and smartphone use. This is specifically not what Weiser aimed for, with the concept he later called 'calm technology'.

### **2.2.2 Calm technology**

Related to ubiquitous computing, overlapping for a part, is calm technology<sup>35</sup>. In short, calm technology is a perspective where technology should help users

differentiate between the information we can do without and the information we really need. Instead of inundating the user with stimuli, calm technology should require the smallest possible amount of attention. Applications should be unobtrusive, create ambient awareness by drawing on our peripheral senses<sup>36</sup>. According to the principles of calm technology, systems should adapt to the culture of users and should allow users time to get accustomed to technology (ibid.).

The fundamental idea of Weiser et al.<sup>37</sup> is to deliver a more humane, indeed 'calm' experience of technology to the user. The excessive use of communication tools is described as what we would call in contemporary terms an information or data overload:

"Information technology is more often the enemy of calm. Pagers, cell phones, new services, the World-Wide-Web, email, TV, and radio bombard us frenetically. Can we really look to technology itself for a solution?" (ibid.)

To emphasize the role of the relationship between the periphery, the space outside and in the centre of attention of the user, Weiser et al.<sup>37</sup> propose to "turn to technology itself" to design technology in a way that information needed to interact with a system can shift from the centre to the periphery of attention. This results in an interaction model that focusses exclusively on the relevant information, and is more serene than the usual "frenetic" technology:

"First, by placing things in the periphery we are able to attune to many more things than we could if everything had to be at the center."

And further on:

"Without centering the periphery might be a source of frantic following of fashion; with centering the periphery is a fundamental enabler of calm through increased awareness and power."

Interestingly, and related to my study, Weiser describes in this context an example of shared media spaces<sup>38</sup> or rather an Integrated Interactive Intermedia Facility (IIIF)<sup>39</sup>, in this case the MBone (for Multicast backBONE)<sup>40</sup>, a set of screens and cameras, set up in remotely located spaces, continuously connected. The purpose of this open audio / visual connection varies from 'soft' functions like awareness, being aware another person is at the other end of the system, of another person being 'connected' to the space one is in, to 'hard' functions like the exchange of data: to present for instance lectures to the other end of the system. Essential is again the effortless shift of attention



from the centre to the periphery. The system can be interpreted as a 'window' to the other side. One can look through it, talk to the other side or ignore it. This concept, a system that allows appropriate, simple interaction, avoiding a data overload for users but at the same time providing a sense of being in control, has arguably value in our contemporary context.

The idea that technology should provide a calm experience rather than the stress it can cause for users does not seem revolutionary from today's perspective. User-centred design is firmly embedded in contemporary design practice. Nevertheless the essence of calm technology, the concept that interaction should be simple, serene and at the same time efficient, is still more a spot on the horizon than a daily reality.

### **2.2.3 Ubiquitous computing, calm technology and the study of the telepresence receptionist**

The general concepts, the theoretical framework of the design and the design process of the telepresence receptionist system relate partly to ubiquitous computing but even more so to the more ideologically oriented concept of calm technology. The ambition to design a system with intuitive physical control, with simple functionality that does not provide the user with an abundance of possibilities was inspired by calm technology (see fig. 8). This happened not so much intentionally, with my notebook in my hand to see whether or not my process and ideas were matching with Weiser's concepts, but functioned more, to stay in his terms, in the periphery. When in doubt, during the design process, I chose for calmness. I rather cut back on the amount of functionalities than add an interaction that would complicate the functionality and distract the user.

Obviously there are alternative ways to look at the design of controls. The focus of this project: simple tangible interaction and the context of media spaces made the choice to look for a theoretical framework in ubicomp and calm technology a logical one, bearing in mind that I wanted to keep a critical attitude towards all theoretical frameworks, including the TUI paradigm. It was my ambition to investigate possibilities, especially of simple and direct control, where some of the positive qualities of TUI play a role but without the stringent straightjacket of the paradigm. This study is certainly grounded in several theoretical frameworks but does not fit neatly into one of them. Calm

technology though, that preceded the introduction of tangible interfaces, is a broad concept that matches the project best, not so much because its descriptions fit that of the telepresence receptionist (see Fig. 8), but more so because the gist of it, the ideology that transpires from the calm technology publications relates to my ambitions: simple, calm, intuitive control of a telepresence application.



**Figure 8: Attention model of users of the telepresence receptionist.**

Furthermore, the implementation process of the telepresence receptionist has a bearing on calm technology. The website dedicated to calm technology describes it quite eloquently <sup>36</sup>:

“calm technology should respect social norms<sup>41</sup>.

- Technology takes time to introduce to humanity.
- What social norms exist that your technology might violate or cause stress on?
- Slowly introduce features so that people have time to get accustomed to the product.(ibid.)”

In the field trial of the telepresence receptionist this relates to ‘the soft implementation’, an extended implementation phase where a new application is introduced to the user group, in close collaboration, allowing final adjustments of the system and the gathering of feedback.

#### **2.2.4 Augmented reality**

The term augmented reality<sup>42</sup> was coined by Tom Caudell and David Mizell<sup>43</sup> in 1992 at the Boeing airplane manufacturing company, introducing a head mounted display that showed the layout of the planes on multipurpose, reusable boards.

Augmented reality has evolved from early applications like Wellner's Digital Desk Calculator<sup>44</sup>, a 'number reader' on a table with video projection and Flight Strips<sup>45</sup> (see section 2.3.2) to more recent handheld augmented reality applications for the smartphone, for instance Layar<sup>46</sup> that projects pre-recorded visuals over live video. Concerning AR, in *Tangible Bits*, Ishii and Ullmer prefer "graspable physical objects as input" rather than purely visual overlays "and in the combination of ambient media with graspable objects".

In 1993, in a special issue of the Communications of the ACM, *Back to the Real World*<sup>47</sup>, it was argued that both desktop computers and virtual reality estrange humans from their 'natural environment'. Computers should be an integral part of the objects that surround us, enhancing their functionality. Wellner et al. (ibid.) argue:

"Computer-augmented environments merge electronic systems into the physical world instead of attempting to replace them. Our everyday environment is an integral part of these systems; it continues to work as expected, but with new integrated computer functionality."

In their monograph *Tangible User Interfaces: Past, Present, and Future Directions* of 2000<sup>48</sup>, Shaer and Hornecker observe, in retrospect:

"This approach was motivated by the desire to retain the richness and situatedness of physical interaction, and by the attempt to embed computing in existing environments and human practices to enable fluid transitions between "the digital" and "the real"."

This 'fluid transition' between 'the digital' and 'the real' can be seen as a vital concept in the design of human computer interaction and returns in the descriptions of TUI, ubicomp and calm technology. From a contemporary context, AR is a technology that is getting more accessible and because there are affordable platforms, the opportunities are still considered extensive<sup>49</sup>.

### **2.2.5 Durrell Bishop's Marble Answering Machine**

From 1992, also described in *Tangible Bits* as an inspiration, stems a project that still stands out as an early example of tangible interaction. The Marble Answering Machine describes the design of a telephone answering machine where the sound files are stored in marbles that can be played, replayed and deleted. Shaer and Hornecker argue the revolutionary innovation of Bishop is in the giving of new meaning to abstract objects:

“Most striking is how Bishop’s works assign new meanings to objects (object mapping), turning them into pointers to something else, into containers for data and references to other objects in a network.”<sup>48</sup>

Bishop thinks beyond the boundaries of the interfacing technologies, the mould from which almost every application at the time originated, and presents a completely fresh concept. In the 1980s answering machines were clunky, unattractive tape recorders connected to the at the time still frequently used table-top, non-mobile, telephone. Bishops’ approach, where he uses relatively large, easy to handle, marbles, relates in that sense to my study: control by means of objects, with a basic design, with a simple functionality.

### **2.2.6 Graspable user interfaces**

The concept where in an interaction system several interactions can be executed at the same time, instead of in sequence, was explained in *Bricks: Laying the Foundations for Graspable User Interfaces*<sup>50</sup> by Fitzmaurice, Ishii and Buxton. They called this space-multiplexed interaction and it is one of the concepts that signals the way to TUI. The paper defines them as:

“..the concept of Graspable User Interfaces that allow direct control of electronic or virtual objects through physical handles for control.”

The authors make a distinction between space-multiplexed and time-multiplexed interaction, arguing that interaction with computers can be seen as either space-multiplexed, allowing simultaneous interaction like the driving of a car where the driver can steer, clutch, shift and accelerate at the same time, or time-multiplexed interaction where the interface “can only perform one task at the same time”.

The WIMP system, the pointer, screen and mouse, is described as a poor instrument to perform certain tasks. The idea of graspable interfaces is not to replace the WIMP model altogether, but to look for higher ground, to see how computers can enhance our human capabilities, instead of replacing them. Computers, according to the authors, should be at our service, make us more creative, productive and improve our quality of life. To do so, computers needed to blend into the reality of our everyday lives. This seems to be one of the central concepts of the alternatives devised for the GUI dominance in the 1990s: computing should be aiding the user in a friendly, unobtrusive way.

It can be argued that the graspable interfaces concept was incorporated by the TUI paradigm: after 1997 the term is rarely applied and its central ideas (and some protagonists) became part of the TUI discourse. Chronologically (see Fig. 7), it is one of the concepts closest to the TUI paradigm.

In the approach of conjoint control, it is theoretically possible to design simple space multiplexed interaction, although I propose it is not a requirement. A simple controller with several parallel input modalities can potentially be the interaction model of a limited functionality, like camera control, where the turning of the camera can be done in parallel with the moving it up and down (panning and tilting).

### 2.3 Tangible Bits: CHI 1997

Ishii and Ullmer's paper *Tangible Bits*<sup>1</sup> is generally seen as the fire starter of the TUI paradigm. The text spoke to the imagination of the CHI community. Looking closer at the 1997 CHI conference program, a number of ideas and concepts were also presented that to a greater or lesser extent acknowledged the limitations of the WIMP interface, introducing alternative, and bespoke applications for particular design questions. Kurtze<sup>51</sup> proposed a haptic solution to allow blind people to work with graphics and Balakrishnan et al.<sup>52</sup> devised a mouse that can handle 3D objects. Fitzmaurice et al.<sup>53</sup> evaluate the graspables they introduced in 1995. It can therefore be argued Ishii (see Fig. 9) and Ullmer were not alone in their observation that the HCI community could benefit from a new set of ideas: their paper fell in fertile ground.



**Figure 9: Hiroshi Ishii at the TEI conference in 2018 in Stockholm.**

*Tangible Bits* highlighted a number of projects at the MIT Media Lab and merged ideas and concepts that were already part of the discourse for a number of years. The paper was ambitious in the sense that it explicitly attempted to set out a new direction for HCI:

“To look towards the future of HCI, this paper will present our vision of Tangible Bits and introduce design projects including the metaDESK, transBOARD and ambientROOM systems to illustrate our key concepts”<sup>1</sup>



**Figure 10: Collection of historical scientific instruments at Harvard University.**

Ishii and Ullmer start out by explaining their inspiration actually originated from a rather nostalgic perspective on the past, from the ‘oak and brass artefacts’ they saw at the Collection of Historic Scientific Instruments at Harvard University (see Fig. 10). They claim users of these instruments:

“must have developed rich languages and cultures which valued haptic interaction with real physical objects”

The authors, using the metaphor of ‘coupling the bits’ for the digital world, with the ‘atoms’ for the physical world, proposed a:

“new view of interface and raised a set of new research questions to go beyond GUI”

This resulted in a shift in perspective of HCI research, already noticeable at the next CHI conference in 1998.

The ‘tight coupling’ between input and output is, although not very precise, a useful metaphor and I have appropriated it for the description of conjoint control. In that context it means quite literally a direct link between the action of a user manipulating the object that functions as controller and the result of this action (interaction) of the system. In conjoint control it means that there is a strictly one-on-one relationship between the action and the result, what I have been calling absolute control. This means the controller preferably should not slide back to a neutral position but that the position of the object indicates the status of the system at all times. This approach in interaction is not intended as a very precise instrument but as an aid in the intuitiveness of the system.

### 2.3.1 MIT Media Lab projects

Three projects highlighted in *Tangible Bits* are as mentioned the metaDESK<sup>54</sup>, transBOARD<sup>55</sup> and ambientROOM<sup>56</sup> systems. MetaDESK uses so called physical icons or phycons on a projected map and a LCD screen, mounted on an arm, that shows the 3D representation of the map, to “push back from the GUI approach”. The system is a working proof-of-concept both motivating and illustrating notions of tangible user interfaces:

“It is designed to tangibly demonstrate and embody a repertoire of new interaction techniques.”

TransBOARD is described as a platform:

“networked digitally-enhanced physical whiteboard designed to explore the concept of interactive surfaces which absorb information from the physical world, transforming this data into bits and distributing it into cyberspace.”

The idea of TransBOARD was to provide a prototyping tool for TUI, a platform that facilitates a relatively fast testbed for what was called interactive surfaces. It consisted of a whiteboard where the strokes of felt pen could be stored in a ‘hypercard’ as a container, in the sense that the container has no metaphorical relationship with the content (see section 2.4.1). AmbientROOM toyed with the idea of peripheral information, making it possible to show the activities of a loved one in a remote location (in the case of the Media Lab a hamster) by an installation suggesting the behaviour of the hamster by using “ambient light, shadow, sound, airflow, and water movement”.

Elsewhere at MIT, more projects centred around tangibility had already been initiated before the publication of *Tangible Bits*. Resnick et al.<sup>57</sup> of the Lifelong Kindergarten, at CHI '98 introduce the term ‘digital manipulatives’, describing them as:

“new manipulatives-with computational power embedded inside-are designed to expand the range of concepts that children can explore through direct manipulation, enabling children to learn concepts that were previously considered “too advanced” for children.”

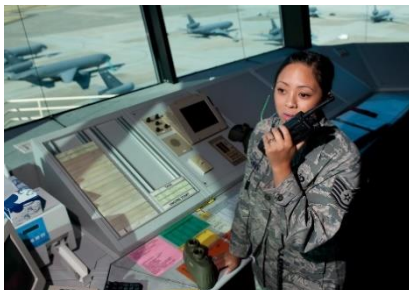
The authors worked on a range of educational TUI: for instance beads with LEDs, that can be programmed or the Bitball, a rubber ball with accelerometer and LEDs that can also be programmed (ibid.).

At the Tangible Media Group, Illuminating Light<sup>58</sup> was a project that combined video projections with objects for several purposes, for instance chess, but also for an application that seems to be cut out for collaborative tangible interaction: the urban planning tool URP<sup>59</sup>, that emulates water flow, shadow or sunlight on tangible objects. The tool specifically shows the direction of the sunlight at any time of day, the behaviour of wind, by projecting data visualisations on objects. The URP has had relatively large follow up, with similar applications like Illuminating Clay and SandScapes<sup>60</sup> and (in Vienna) the ColorTable<sup>61</sup> in 2008.

In hindsight many of the MIT projects that aimed to ‘catch’ the data from the digital world and translate them into atoms, 3D objects that could somehow add to the functionality, like MetaDESK, AmbientROOM and TransBOARD were visionary, in the sense that they foresaw and created alternative interaction models. Most of the ideas did not result in real-world applications but can be seen as baby steps in the development of alternative interaction models. One can even argue that the concepts were too far ahead of their time. Some of the prototypes had attractive features that to this day have not been surpassed. Landscape architects for instance, but also organizers of outdoor events and city planners, nowadays use VR representations to get an idea of their designs, but lack the collaborative possibilities of URP. In that sense, the URP is still a concept that stands out as an example of a successful early TUI.

### **2.3.2 TUI projects**

Also outside the MIT sphere, researchers studied TUI at the end of the millennium. Mackay et al.<sup>62</sup> in 1998 worked on related projects with what they call ‘interactive paper for three real life applications’. One of the applications



**Figure 11: Paper flight strips: a generic air traffic control stacking system.**



was called 'Ariel', facilitating augmented technical drawings for construction engineers. Video Mosaic was an application that provided augmented storyboards for video producers. An interesting project was 'Caméléon', where Mackay et al. augmented flight strips for air traffic controllers.

Mackay et al. (ibid.) argue that paper has a number of affordances<sup>63, 64, 8</sup>, inherent characteristics, that users, although aware of the possibilities of digital applications, cannot ignore. For this reason, the authors set out to augment, to project, additional information on paper. Flight control systems at smaller airports use a system, next to a range of digital solutions, where flight controllers stack tokens with hand written strips on them in order to have a physical overview to handle the safe sequence of taking off and landing of airplanes (see Fig. 11). The authors designed a hybrid system where they added necessary information to the paper strip. They conclude:

“Augmented Reality provides a powerful alternative to the "keep it or replace it" choices traditionally faced by system designers.”

At CHI '98 were furthermore presented the HandJive project<sup>65</sup>, “a haptic device for interpersonal entertainment”, the InTouch<sup>66</sup>, that provided human interaction over distances with haptic feedback and the InSight Lab<sup>67</sup>, a design tool for collaboration on complex design projects, combining different data in an organized way to provide an overview of the structure. The emphasis of many early TUI projects is on those functionalities: tools for collaboration where different forms of data are brought together that can be manipulated in parallel, space multiplexed, visualized by a hybrid system. These qualities from a contemporary perspective resemble the tools in remote collaboration, although those are still mostly screen based.

## **2.4 Categorization of TUI: taxonomies and frameworks**

Around the turn of the century, a string of categorizations appeared, to help designers and researchers assess TUI. It is possible that this development is significant in the sense that there must have been confusion of what a TUI actually is. Knobs and buttons already existed and needed no new paradigm, it was clear that TUI were meant to be much more.

Fitzmaurice et al. (see section 2.2.6) already in 1995 proposed a conceptual framework for graspable user interfaces<sup>50</sup>, where they divided graspable interfaces in space and time multiplexed. The frameworks that emerged from 1999 onwards, took the paradigm apart, each from their particular perspective. In 2006, the urge to categorize stops quite abruptly (see Fig. 12). In relation to this study it is clear that our perspective on the control of the telepresence receptionist does not fit most frameworks, in the sense that this form of direct manipulation is not covered by most of them. Nevertheless, the TUI taxonomies were helpful to gain insight into how the HCI community approached and validated TUI.

#### **2.4.1 Holmquist et al.: containers, tools and tokens**

In 1999, 2 years after Ishii et al.<sup>1</sup> coined the term TUI, Holmquist et al.<sup>68</sup> introduced one of the first frameworks of how to classify objects that contain digital information. The paper is not specifically written from a TUI perspective but more in general about objects in digital systems containing digital information. Holmquist et al. recognize:

- Containers, meaning any object that holds digital information, but has no direct relationship with the information: “the physical properties of a container do not reflect the nature of the digital information it is associated with.”
- Tokens, an object that represents and resembles information and “..that physically resemble the information they represent in some way.”
- Tools, used to actively manipulate digital information, usually by representing some kind of computational function.

The authors argue that these distinctions are at times hard to assess:

“Sometimes the distinction between a tool and a token or a container will blur, since when a physical object is attached to a virtual, direct manipulation of virtual properties using the physical representation might become possible.”

To attribute meaning to the technology that enables us to relate to the data, Holmquist et al. furthermore propose the term faucet, being the instrument that channels the information to the user:

“A set of access points for the digital information associated with tokens. These access points we will call information faucets, or faucets for short.”



**Figure 12: Frameworks for TUI.**

The framework of Holmquist et al. proposes a beginning of the TUI vocabulary and some of the abstractions that are still functioning in the TUI discourse.

#### **2.4.2 Ullmer and Ishii’s Emerging Frameworks**

Ullmer et al.<sup>69</sup> untangle the concepts of GUI versus TUI, the graphical interface versus the tangible alternative, by differentiating the interaction in a ‘model’, ‘view’ and ‘control’ part of the GUI (where the model is the digital system, the go-between of the view and the control, the out- and the input). For tangible interfaces Ullmer et al. (ibid.) argue that they:

“.. give physical form to digital information, employing physical artifacts both as representations and controls for computational media. TUIs couple physical representations (e.g., spatially manipulable physical objects) with digital representations (e.g., graphics and audio), yielding interactive systems that are computationally mediated, but generally not identifiable as “computers” per se.”

With the landscape architects tool URP (see section 2.3.1) as an example Ullmer et al. stress that “physical representation” is one of the distinctive

factors of TUI. The URP consists of physical models of buildings and a workbench providing representations of other factors like the direction of the sun.

The GUI and the TUI interaction model is illustrated by respectively the MVC (model-view-controller) and the MCRpd (model-control-representation, physical and digital) model:

“MCRpd highlights the TUI’s integration of physical representation and control. This integration is present not only at a conceptual level, but also in physical point of fact – TUI artifacts ***physically embody*** both the control pathway, as well as a central representational (information-bearing) aspect of the interface.”

What transpires from the MCRpd model is that the physical representation can be a combination of graspable, physical, artefacts, digital information (video overlays) and the control of the system.

The other example Ullmer et al. provide is that of mediaBlocks, ‘a tangible interface for manipulating collections of these physically embodied videos, images, and other media elements.’ Mediablocks are what they suggest: blocks, that have no relationship with the content they represent in their shape or form, on the contrary: they can contain different content in every other session. This application is relatively simple, aimed at exchange of different media between platforms. This token value establishes the other end of the physical representation scale that begins with real physical representation where the object refers to a the functionality it represents, like in the URP. This scale is also worked out in Fishkins taxonomy (see 2.5.4) where he differentiates between none, noun, verb, noun and verb and full metaphors. He argues that it is possible there is no metaphoric relationship with the object at all, like in Mediablocks. Furthermore there can be a metaphoric relationship in shape, in action (verb) and noun and verb, like in the URP, and full metaphor like in Illuminating Clay.

Ullmer et al. also formulate key other characteristics to categorize TUI as such as ‘spatial’, ‘constructive’, ‘relational’ or ‘associative’ In this categorization, spatial interfaces have a direct relationship with the underlying meaning. Relational systems have a more abstract relationship with the underlying meaning and constructive systems are modular, so can consist of containers that together generate meaning.

Ullmer et al. describe the possible domains for TUI, but a very direct form of interaction, an application area for simple control of digital systems by means of tangible objects, or controllers, is not discussed. If the design of the controller of the telepresence receptionist is analyzed along these lines, there is a 'noun' metaphoric relationship between the half sphere shape, suggesting the movement of 'looking around' when manipulating the camera and screen on the other end and ringing of the half sphere shaped hotel bell.

In summary, this early framework for tangible interfaces proposes a, in some contexts, useful categorization of the metaphoric quality and token value of a TUI. On the other hand there are insights that provoked reflection, in particular when the authors describe engineering-driven design, where the electronic and other practical issues, restrict the design value of the TUI. This is an interesting observation and I recognized it as an issue in our design process, especially in first design cycles of the telepresence receptionist when my limited knowledge of electronics and the rudimentary equipment I worked with restricted the design capabilities. The version that was finally evaluated was more aimed towards the interaction than the design, also because of my choice for off-the-shelf components. Ullmer et al. suggest that these two factors cannot be separated. A design is a design, including its interaction but certainly the way it is designed. My perspective on the matter is that a study like the telepresence receptionist is always a trade-off between funding, ambition, craftsmanship, time and the scope of a study. Certainly many different design possibilities for the controller were explored, finally choosing a wooden controller, but with the awareness of the restrictions, of the factors that limited the final design of the system. These limiting factors were partly intentional as the ambition was to design a simple, scaled down system by means of modular, off-the-shelf components. But even so, a more elaborately designed, aesthetic controller, integrated with the functionality, is one of the ambitions for further development.

### **2.4.3 Fishkin's Taxonomy**

One of the more elementary frameworks is the taxonomy of Fishkin<sup>70</sup>, incorporating Weiser's Calm Technology (see section 2.2.2) in this categorization. Fishkin's taxonomy is based on two axes: the embodiment and metaphorical quality of a TUI. The embodiment category is subdivided in: full,

nearby, environment and distant. The metaphors are divided in none, noun, verb, noun and verb and full, relating to Ullmer et al. (see 2.4.2).

An interesting proposition is that Fishkin argues he devised this framework as a tool for researchers, not exclusively in HCI, but much more to open up the TUI field to researchers in domains where TUI in his opinion have their proper destination: “..the communities of industrial design, kinesthesiology, architecture, and anthropology.”

I argue that the studies of alternative interface models might have been too much the exclusive territory of HCI, neglecting other (closely related) domains and areas. Fishkin’s taxonomy can be instrumental for collaborative, transdisciplinary design processes<sup>71</sup> in this direction.

The controllers of the telepresence receptionist (see Fig 13) can be positioned in Fishkins’ taxonomy. There is distant embodiment, the action that is a result of the interaction is ‘over there’, in a distant space. The metaphoric quality of the controller is in the movement (verb) of the controller but to a degree also in its shape (round, like the bell, it is connected to and is, by the way, the counterpart of the controller at the receptionists end.

metaphor embodiment	none	noun	verb	noun and verb	full
full					
nearby					
env.					
distant					

**Figure 13: Fishkins’ taxonomy applied to the telepresence receptionist.**

#### 2.4.4 The TAC paradigm

Shaer et al.<sup>72</sup> build on the foundations laid by Holmquist<sup>68</sup> and Ullmer et al.<sup>69</sup> proposing a unifying framework, the token and constraint (TAC) paradigm, devised to identify the basic properties of TUI, encompassing all TUI.

Shaer et al. base their paradigm on the notion that a TUI may be described as a set of relationships between physical objects and digital information, much

like the framework of Holmquist et al.. It sums up the challenges of the design of TUI (that can also be interpreted as opportunities):

- TUI are interlinked virtual and physical worlds: they combine graspable and virtual properties.
- Can have multiple behaviours: the behaviour of a physical object is not determined by the nature of the physical object alone, but also by that object's interactions with other physical and virtual artefacts.
- Multiple actions: TUI are in general 3 dimensional, allowing much more and different interactions than GUI.
- No standard input / output devices: TUI can use a different (set of) technologies.
- Continuous interaction: the input of TUI can be complicated and abundant, programmers have to cope with that and oftentimes have to revert to low level technologies.
- Distributed interaction: the input of TUI is often parallel, meaning different input devices can perform the tasks simultaneously. Interaction models based on GUI are in general serialized in one stream.

One of the terms the paradigm builds on is a 'pyfo'. A TUI can comprise several pyfos. A token, in the terminology of the TAC paradigm is a pyfo that represents digital information or a computational function in an application. A constraint is a pyfo that limits the behaviour of the token with which it is associated. This looks confusing but can be understood as the affordances of the pyfo: the inherent functionalities of its (physical) properties. Variables are the digital information coupled with tokens. A TAC is the relationship between a token, its variable, and one or more constraints.

The TAC paradigm allows a quite detailed but abstract breakdown of the properties and functionalities of TUI, aiding designers in the evaluation in the design process. Because the methodologies of the design process itself are positioned on the background, it is one of the frameworks where it is hard to position the telepresence receptionist. In the approach of conjoint control there is a possibility that is more productive to assess how the interaction model was designed, what the role of the user was, how flexible the process was. In other words: the focus of the TAC paradigm does not completely apply to the approach of our study: a user-centred approach where the design of the interaction is aided by input and adapted on-the-spot.

#### 2.4.5 Wensveen et al.

A descriptive approach has been proposed by Wensveen et al.<sup>73</sup>, who introduce the term 'natural coupling', meaning:

“...appearance, the action possibilities, the action and the function are all naturally coupled the inherent relationships of object and functionality. “

Using the example of simple paper cutting with scissors, they define a number of aspects of natural coupling:

1. Time: the application and user's reaction to it coincide in time: the moving of the paper with one hand, the cutting with the scissors with the other hand, all happen at once.
2. Location: the scissors, the paper and the user are all in the same location.
3. Dynamics: the dynamics of the interaction, the cutting and the result of it (position, speed, acceleration, force) are closely interrelated: smooth cutting makes for a smooth result, haphazard cutting for frayed edges.
4. Modality: this means the sensory perception of the action is closely tied to the action, the sound and the haptic experience provide information about the interaction.
5. Expression: the user is able to differentiate between certain types of action, a certain way of action, for instance with the utmost dedication and care, can provide a similar result.

The authors acknowledge that the example of paper cutting and the aforementioned aspects are not in its entirety transposable to TUI: the digital component can allow shifts in these couplings. Their framework furthermore adds another ingredient: feedback and feedforward, or as they put it: “information to guide the user's action to the function.” The authors present: feedback, in its classical meaning in HCI as the return of information about the result of the process. They distinguish:

- Functional feedback, in their example when a tv is switched on the appearance of images on the screen.
- Augmented feedback, the LED light on the button of the tv.
- Inherent feedback, the ‘feel and the sound of the button being pushed’.

Feedforward is described as a lighter version of affordances: the pointers that direct the user to the interaction:

- Inherent feedforward, is described as a limited interpretation of the concept of affordance.



- Augmented feedforward: the suggestions an interface can give for further use.

- Inherent feedforward, a more semantic relationship with the interaction.

Wensveen et al. devised a system that categorizes the idea of natural coupling, and that is interesting in the scope of this study because conjoint control inherently has a coupling, a close relationship between the action and the effect of the action. They also categorize the overall position of the interaction in the domain and they specify interaction styles. The graphic representation of their framework, although rather enigmatic at first sight, can be an aid for designers to gain detailed insight into the inner workings of their (tangible) product. The authors explicitly argue for a tangible approach in HCI:

“..enriching the action possibilities which exploit the human repertoire of actions and the inherent feedback based in the richness of the physical and tangible world.”

The concept of natural coupling allows a closer break down of conjoint control. Therefore, for practical purposes in the context of my study the framework of Wensveen et al. provides an interesting perspective, for it actually incorporates very simple styles of interaction.

#### **2.4.6 The Framework of Hornecker and Buur**

Lastly, Hornecker and Buur<sup>74</sup> devised a broad framework for TUI emphasizing the spatial and the social qualities of tangible interfaces. They recognize four mutually inclusive themes for TUI:

- Tangible manipulation refers to the material representations with distinct tactile qualities, which are typically physically manipulated in tangible interaction.
- Spatial interaction refers to the fact that tangible interaction is embedded in real space and interaction therefore occurs by movement in space.
- Embodied facilitation highlights how the configuration of material objects and space affects and directs emerging group behaviour.
- Expressive representation focusses on the material and digital representations employed by tangible interaction systems, their expressiveness and legibility.

The framework is meant:

“..as a conceptual aid that may provide us with a handle for getting to grips with the user experience and social aspects of tangible interaction.”

Hornecker and Buur's work can be helpful for designers of interactive systems to provide a quick insight into the conceptual structure they are working in. However, for the categorization of the telepresence receptionist it lacks the proper 'handles': the methodology of control, the embodiment in relation to the system, the absolute control of simple interaction systems.

Because the authors facilitate a broad view for researchers of different disciplines however, their framework can enable researchers to contextualize their study. Hornecker and Buur provide a tool for the analysis of the user experience and social aspects of tangible interaction: what the TUI does with the users in the environment in which it is used. This angle on interaction models opens up the paradigm for a more user oriented approach, a perspective this study highlights as well.

#### **2.4.7 The telepresence receptionist and the frameworks**

The TUI paradigm was an inspiration for this study, especially in its early stages. But over the course of the process, it became more and more clear that there are inconsistencies between the TUI paradigm and the approach I took with the telepresence receptionist. The frameworks were in this respect helpful to identify the discrepancies with the TUI paradigm. Applying the frameworks to the concept of the telepresence receptionist shows a variety of results, but one major tendency: most of the frameworks emphasize the properties of TUI as an end product but the focus is usually not on the process, the design cycles resulting in a TUI. Conjoint control features a strong user oriented, collaborative, design process and its framework highlights this (see chapter 5).

Furthermore, there are frameworks that show where there are overlaps. The taxonomy of Fishkin (see section 2.4.3), provides a clear image of the position of the control of the telepresence receptionist on the axes of embodiment (see section 2.7) and metaphor. The framework of Wensveen et al. categorizes the simple interaction model of the telepresence receptionist in the most precise way. It focusses on the interaction as such: first it proposes the term of natural coupling where the action is taxonomized. Then it analyzes in depth the way

the action results in feedback (or is preceded by feedforward) and how this leads to an interaction model. The graphical representation of the framework is rather complicated: a simplified version would be helpful, also for designers and builders. The framework of Hornecker and Buur however, aimed at the classical TUI with multiple input modalities, emphasizes from a more sociological point of view, the role of the user and has therefore also theoretical analogies with the approach of this study.

## **2.5 Related paradigms**

The TUI paradigm is a dynamic concept that is continuously developing. A yearly showcase can be seen at the TEI-conference (on Tangible, Embedded and Embodied Interactions) where design and art related projects are shown and papers are being presented. Because there are various directions and contexts, I discuss the two post-*Tangible Bits* perspectives that apply to my study and have been conceived in this century.

### **2.5.1 Slow technology**

In 2001 Hallnäs and Redström<sup>75, 76</sup> introduce the slow technology paradigm, categorizing what had also been framed as ambient technology. Related to the TUI paradigm and the calm technology concept of Mark Weiser<sup>35</sup>, the authors advocate a more deliberate, reflective interaction model:

“slow presence of elementary technology as a tool for making reflection inherent in design expression.”

Slow technology projects are subdivided into ‘reflective technology’, ‘time technology’ and ‘amplified environments’. Interestingly, the element of sound is given attention: the authors present the term ‘soniture’ (as opposed to furniture):

“we mean the more or less movable things in a room that give the room its sounds, the sounds that equip it for living and makes it into the particular room it is.”

and informative art’:

“With informative art, we have tried to “amplify” an art object’s capability to present information about its location.”

Guidelines for Slow Technology are described as:

- Focus on slowness of appearance (materialization, manifestation) and presence – the slow materialization and design presence of form.

- Focus on aesthetics of material and use simple basic tools of modern technology.

From the perspective of this study, these guidelines apply partly to the design approach of conjoint control: the controller has a relatively rudimentary appearance (although not slow) and there is a focus on simple basic tools.

Slow technology has its overlaps with calm technology but adds a more active reflective modality to it: the user is stimulated to reflect. I posit that these more subtle forms of interaction and feedback are fruitful possibilities for future work, but even more so when these reflective modalities are coupled to our bodily abilities, as happens in somaesthetic interaction design.

### **2.5.2 Somaesthetic interaction design: design with the body**

Kristina Höök in 2018 published *Designing with the Body*<sup>77</sup> where she makes a case for somaesthetic interaction design, a design philosophy “involving our bodies, movements and biodata” that calls for “entirely new design processes fundamentally different from those now prevalent in the HCI and interaction design fields”. Höök outlines the importance of the bodily experience in design and how designers can develop somaesthetic sensibilities, ‘training’ themselves to be a somaesthetic designer. She argues that contemporary design methods are based on symbolic, language-oriented, and visual feedback and that there is an qualitative shift needed towards an “..experiential, felt, aesthetic stance permeating the whole design and use cycle.” a methodology resulting in a slow, thoughtful design process that takes into account fundamental human values.

Höök furthermore points out that modern technology, in particular the emerging internet of things, for instance the functionalities of a smart home, is overloading users with interactions calling for our attention. The smoke detector beeps every night to show it is still functioning, the washing machine signals when it is finished and the fridge warns that the door is left open. This dialogue we have with our smart systems consumes time and energy and might not even be an improvement of our experience, the implicit promise of these systems.

The attention in the design community for soma design is no coincidence. The commercial methods of product design, where the design of computer

applications or systems is first and foremost aimed at keeping the costs of production as low as possible, are losing momentum. Consumers are more aware that they do not have to accept applications that have frustration and stress built in. There is a fundamental shift in attitude towards the role of technology. Höök propose, that technology should be part of the issues it creates itself. To achieve this, we make a pact, users physically merge with technology.

As Höök argues, users do not mind a dialogue with the products they own, but they object to not having a choice, and what certainly stresses them out is to continuously be addressed as though there is something they owe to technology. Users want the functionality they acquire to be intuitive, connecting to their bodily experience and capabilities. Interaction design has to provide the functionality they chose, not a variety of functions where they have to discover in a web of menus and sub-menus, the function they actually want or need to use.

## **2.6 Controllers**

In HCI, controllers, interfaces that allow direct control of a digital application, are arguably a genre of its own, especially developed in the domain of gaming<sup>78</sup>. There is work that makes an effort to map the impact of different controllers<sup>79</sup>. Others focus on the actual experience of controllers in video games<sup>80</sup>.

A relatively new domain is the control of telepresence robots, that are appearing at conferences and other events, generating the feeling of presence and allowing users to roam around and interact with others, whether they are other telepresence robots or real persons. My perspective is that the field of controllers, with its specific terminology and research focus, comprises a highly context specific and independent domain, related to but not overlapping with the TUI paradigm.

### **2.6.1 Controllers for camera control and in telepresence**

Remote controlled camera systems, for instance for webcasts where a talk show with several cameras is streamed, or for the monitoring of buildings where cameras can be aimed and zoomed in, typically use a joystick.

Sometimes joysticks are applied as a discrete controller, with pan tilt zoom function (PTZ), sometimes integrated in a switchboard with other functionalities, like for instance switching between cameras, preview and actual (online) camera (see Fig. 14). New applications combine touch screen functionalities with buttons but still apply a joystick for the actual control of the camera. For telepresence, as mentioned, GUIs and joysticks are applied, but have few commercial applications.



**Figure 14: Joystick in a unit for camera control.**

Hughes et al.<sup>81</sup> performed a study of the control of robotic camera control, but only used a (Logitech) joystick. Rae et al.<sup>82</sup> extensively looked at the control of telepresence robots in a controlled environment, comparing several stages of embodiment:

- Non-embodied.
- Physically embodied with local control (the telepresence robot is controlled by the user in its vicinity).
- Remote embodied where the telepresence robot is controlled by a remote user with a joystick.

The researchers are focussed on trust and not on the controllers of the robot as such and regard a joystick as an example of embodied control. They conclude that the embodied local control generates more trust than other GUI-based control options. I elaborate on embodiment in section 2.7.

## **2.6.2 Alternative approaches for controllers**

Another emerging context where controllers play a dominant role is the control of drones: small remote controlled unmanned quadcopters for various purposes. Because controlling a drone requires a rather sophisticated skillset, the actual control, performed by a joystick and a set of additional buttons and

sliders, is supported by an ever expanding array of software<sup>83</sup>, drawing on elaborate algorithms. This approach could, in the near future, arguably be applied to the control of telepresence applications. A conjoint control approach could also be applied to the design of controllers for human-robot interaction in general, where it makes sense to combine a certain degree of embodiment with intuitive and precise manipulation.

## 2.7 Embodiment

In the preceding sections, the term embodiment shows up frequently as one of the qualities of interaction models. But what is actually understood as embodiment in the context of HCI? Paul Dourish, in *Where the Action Is, the Foundations of Embodied Interaction*<sup>84</sup>, extensively analyzes the different approaches of the term embodiment in HCI. His ambition is “to support the design and evaluation of new systems”, by giving system designers and developers “tools to understand and analyse their design”. Dourish paints a historical picture. Interaction with computers evolved from what he calls the soldering iron, the way to interact with the first primitive rudimentary computational machines, to systems like GUIs and TUIs. This opened up the use of computers for large groups of people. To facilitate this, HCI incorporates a growing range of human skills and abilities in interaction with computers. Our ratio is not enough to invest in our interaction with computers, our brains cannot be separated from our physical and social abilities. This implies interaction with computers cannot do without embodiment. Dourish argues embodiment in interactive systems is relevant for three reasons:

- Design of systems cannot be seen independent of the physical, social and organizational environment it is positioned in.
- Embodiment shifts the attention of the programmer and the designer to the real world, to real cases where the interaction takes place.
- As mentioned above, the separation of mind and matter, of our ratio and our physical abilities, is artificial. When interacting with the world around us, and also with computer systems, we generally use a variety of capabilities.

This is a broad approach of embodiment, indeed explaining what the term in its widest interpretations encompasses, and one fitting the context of my study. My ambition was to study the use of the controller in the ‘physical,

social and organizational environment' that Dourish argues is indispensable for the understanding of the interaction model.

Embodiment is not by any standards a new term, and it has been extensively explored in phenomenology, as Dourish puts it:

“a branch of philosophy that is principally concerned with the elements of human experience.”(ibid.)

In different disciplines, the actual meaning of the term 'embodiment' varies, sometimes only slightly, sometimes significantly. In psychology<sup>85</sup> and in – related - cognitive science<sup>86</sup> the term embodiment, in short, emphasizes the role of our bodies, our physical being, in the experience of for instance emotions, rather than attributing these experiences solely to our mental capabilities. Embodiment is a vital element in the second wave of cognitive science that advocates a holistic approach rather than first wave of cognitive science, that is exclusively looking at cognition in a measurable, disembodied way. The term 'embodiment' is also frequently used in social sciences and health, where it is seen as a part of the narrative people build around their illness<sup>87</sup>.

In the arts, the concept of embodiment particularly plays a role in the media art domain, as extensively described by Penny<sup>88</sup>. In media art, embodiment can be interpreted as the way the spectators, the persons experiencing the artwork, “have integrated the object and its behaviour into their own sense of self.” In this perspective, the artist “brings the person into the artwork,” (ibid.) becoming a part of it. This is – still - seen as one of the interesting approaches for media art<sup>89</sup>.

Designer Theodore Watson<sup>90</sup> uses embodiment quite literally in an interactive game for children by combining it with physical objects. In his interactive installations, he projects video images on objects that can be used by the spectator, or players, to interact with the work. In his work *Funky Forest* from 2007<sup>91</sup>, children can use their bodies to direct the growth of a tree and in their experience, they *are* the tree. They can also use objects, 'stones' to manipulate a 'river'. The production of this type of digital design is highly specialized: Watson wrote, together with artist Zach Lieberman and Arturo Castro an extensive C++ library, called openFrameworks<sup>92</sup>, to make his work possible.





**Figure 15: Funky Forest, a playful environment where the user literally ‘embodies’ a tree.**

These efforts indicate also that the relationship between embodiment, the physical, and the digital, is at times problematic. The digital is still closely related to screens, to the 2D representation of ideas and concepts. For artists and designers who seek to integrate physical space with the digital, this not only means a conceptual challenge but also a technical one. Many platforms and off-the-shelf technologies are geared towards screen based, graphical interaction. To design embodied 3D applications often implies one has to improvise with existing technologies or to DIY specialized technology.

### 2.7.1 Embodiment in tangible interaction

As mentioned above, embodiment is generally acknowledged as one of the defining features of tangible interfaces. The leading conference on tangible interfaces, even incorporated embodiment in its name (Conference on Tangible, Embedded and *Embodied* Interfaces - TEI). In Ishii and Ullmer’s *Tangible Bits*,<sup>1</sup> embodiment is mentioned, but not elaborated upon, related to Bishops Marble Answering Machine (see section 2.2.5).

Many taxonomies and frameworks for TUI recognize the central role embodiment plays in the design of TUI. In Fishkin’s Taxonomy (see section 2.4.3) for TUI<sup>93</sup>, for instance, embodiment is proposed as one of the axes (the other one is metaphor) that categorize a Tangible Interface. Fishkin describes embodiment stricter than for instance Dourish:

“To what extent does the user think of the states of the system as being “inside” the object they are manipulating?”

In other words: is there in the system a relationship between the controller (the object the user manipulates) and the status of the system, the result of this manipulation? Although this description is somewhat reductionist, the

categorization of embodiment Fishkin proposes, with its description where the control is firmly related to the result, the output, is applicable to the direct control of the telepresence receptionist.

Shaer and Hornecker<sup>94</sup> in their monography *Tangible User Interfaces: Past, Present, and Future Directions*, drawing on Dourish, also emphasize the role of embodiment as one of the most essential factors in tangible interaction:

“The sense of touch is our primal and only non-distal sense — touching results in being touched. (...) Furthermore, tangible interfaces allow us to utilize our manual, and more general, bodily intelligence...”

The concept that users, apart from their cognitive skills, incorporate their bodily perception in interaction with computer systems, that they cannot be seen apart from their physical abilities and the perception of those, while interacting with computer systems, is arguably one of the fundamental concepts in our perspective on tangible interaction, and in conjoint control. Related to this, there are various levels to interpret embodiment in this context: from a relatively simple, one-on-one, relationship between object and the output it generates, to more elaborate systems that facilitate the role they play in the environment and its social structures.

### **2.7.2 Embodiment in telepresence**

Embodiment in telepresence is generally described and categorized, like by Biocca<sup>95</sup>, or Haans and IJsselsteijn<sup>96</sup> as a multi-levelled phenomenon. Because telepresence depends on the concept of ‘presence’, communicated over distances, inherent embodiment plays a role in all telepresence applications to a greater or lesser extent. A relevant question for my study might be what exactly the role is of the illusion of being present, the experience of embodiment, in a telepresence system. Is a degree of this quite literal interpretation of embodiment a requirement for intuitive use of the telepresence receptionist? And how does this intuitive use manifest itself? In our study, users of the conjoint, embodied controller report to feel more ‘in control’ than when they are using a, in our definition, less embodied joystick. This implies that embodiment does not support control as such but the ‘feeling of being in control’, the experience of knowing the functionality of a system and having the skills to control it. This can be underpinned by the observation that in the field trial of the telepresence receptionist, users appreciated the embodied control, although they experienced it as less accurate.

### **2.7.3 Embodiment in the approach of conjoint control**

In conjoint control, embodiment refers in particular to the broad description of embodiment as described by Paul Dourish<sup>84</sup>: the role of the interaction in its environment, the physical world. Paul Dourish acknowledges embodiment as one of the cornerstones, or even the 'raison d'être' of innovative interaction models. Our physical abilities are a vital element in our engaging with the world and embodiment is the designated quality to support that when engaging with computers. He presents an inclusive view: our elementary skills that allow us to control computer systems, our tactile and haptic senses, cannot be separated from our ratio. This view, as mentioned, fits the approach of this study: the embodiment of the telepresence receptionist is not only in its direct use and the relation between the controller and the screen it manipulates, it is also in the environment, the role the complete system plays in the context of the reception desk, the users and the organization it functions in.

Conjoint control stresses the process, not only in the design of the system, but even more so the deployment, where the environment, the users and the social relationships are acknowledged. Embodiment plays a role on two levels:

- Controllers are 'things', objects. The control relates to the result of this action, e.g. 'looking around' with the telepresence screen by turning the controller.
- Conjoint control is an approach that incorporates the environment where the system is deployed in and acknowledges the social and organizational factors that play a role in the interaction with the system.

The embodied properties of conjoint control are directly related to its physical properties, the environment, the social context and the functionality. A system is deployed in a physical space, acknowledging the users and the social relationships they engage in.

In conjoint control, there is a relationship between the controller, the user, the system she manipulates and the space the system is positioned in. When for instance controlling a remotely controlled camera in a recording studio, the person using the physical controller is experiencing the use of the system in the particular space.

There is a more direct embodiment in the conjoint control approach: a direct relationship between the controller and the hardware it manipulates. The simple control provides clear, embodied, feedback, meaning a one-on-one relationship with the effect of the control. In other words, the controller is experienced as part of the object it controls. In the case of control over networks, like with the telepresence receptionist, the quality of the experience is closely related to a fast network, to allow low latency.

#### **2.7.4 Latency in conjoint control and telepresence**

When we see embodiment in conjoint control and telepresence as a defining element, latency, the delay between action and result, can typically be one of the complicating factors<sup>97</sup>. The practical implications are straightforward: the lower the latency between input and output, the higher the chance the user will experience the feeling of embodiment in the control of the system. When we manipulate an interface and the output – and feedback - follows noticeably late, a user will have trouble with the interaction: the chain of cause and effect is disturbed, confusing or misleading the user<sup>98</sup>.

For applications like telesurgery<sup>99</sup>, latency levels should be lower than 300 milliseconds not to hamper the process, for making music, the threshold is about 25 milliseconds. Hitting an electronic drum pad and hearing the sound, for example, should not have more delay than 25 milliseconds<sup>100</sup>.

The issue of high latency in applications<sup>101</sup> has only been tackled in the past 10 years, with the production of faster hardware and network connections (fibre optic, 5G). The internet in its entirety, however, is still notoriously slow and especially unreliable. Connections can show short periods of what is called *downtime*: very slow or no connection. Because embodied interaction relies on a one-on-one relationship between interface and the object it controls, embodied interaction in telepresence applications over the internet were until recently problematic.

For the telepresence receptionists' audio / video connection, the latency levels between the two ends were low, especially for the video connection: between 15 and 25 milliseconds. The reason was that we installed its own streaming server, using the local area network (LAN). But these latency levels were also influenced by the activity on the local network. The control of the other functions (bell, panning of the screen) overall showed relatively low latency. However, in a system that consists of several elements, other factors also play

a role, like the latency of the start-up of the electro motors that power the turning of the screen. It is all the latency levels put together, of the audio / video and the control of the screen and the bell that makes the overall experience of the 'slowness' or 'fastness' of the system. Although I tried to keep latency levels as low as possible, improvement is possible, especially in fitting the individual off-the-shelf elements more precisely with the bespoke parts of the system.

## **2.8 Theoretical foundations**

The fundamental theoretical inspiration for this study comes for a large part from the concepts described in this chapter that advocate simple, embodied interaction, for digital systems with a clear, distinct function. In this framework the importance of the process, and the role of the user is highlighted.

The other central concept of the system I built for this study: telepresence or remote collaboration has its own body of theoretical work. Some of the texts that relate to this study are described in the next chapter.

# 3. Remote collaboration, from telepresence to media spaces

## Introduction

The telepresence receptionist is based on the concept of telepresence, a relatively ancient term, referring in general to all technologies that makes the user experience presence in another location and perform tasks. Cognitive scientist and co-founder of the MIT AI lab, Marvin Minsky, coined the term telepresence in 1980<sup>102</sup>. In his original article called 'Telepresence' for Omni Magazine, he describes telepresence straightforwardly as a way to use robotics and video technology to perform tasks over distances. Minsky provides an overview of possibilities for telepresence, while mentioning that technology at that time was not advanced enough for more elaborate tasks:

“Present devices (of telepresence - SN) are so clumsy that they are used only when nothing else works.”

But he concludes:

“Eventually telepresence will improve and save old jobs and create new ones. Later, as we learn more about robotics, many human telepresence operators will be able to turn their tasks over to the robots and become supervisors”.

Minsky presents a utilitarian view. He envisions telepresence as a combination of technologies that allow operators to perform very practical tasks that otherwise could not have been done at all or only at considerable human cost.

As an example, Minsky applies the telepresence concept to the mining industry but also to the, in the 1980s and 1990s highly controversial, context of nuclear power plants, where in his view, a telepresence robot could be the ideal employee. In the future, telepresence robots would be more efficient and have advantages like being able to perform tasks in high risk environments, not sensitive to radiation or air pollution. Telepresence applications would be able to handle assignments that humans can't, because they are for instance

too delicate or too heavy. Minsky even foresees that telepresence robots would prevent stealing at the workplace from the employer:

“If no one were in the buildings, no one would be exposed to radiation. Then we could all stop quarrelling about "tolerable" and "threshold" doses. If nothing enters or leaves the reactor except by way of telepresence machines, no one can steal anything.”

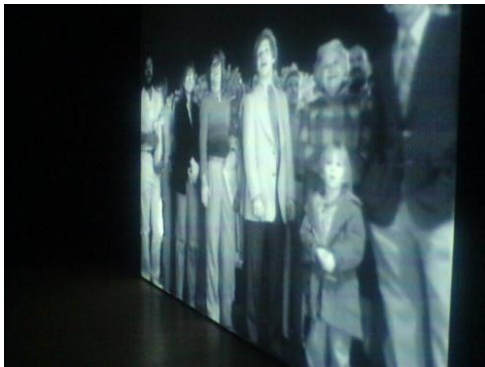
Minsky estimates that the development of a sense of ‘presence’ is the toughest issue to tackle for telepresence developers:

“The biggest challenge to developing telepresence is achieving that sense of "being there." Can telepresence be a true substitute for the real thing? Will we be able to couple our artificial devices naturally and comfortably to work together with the sensory mechanisms of human organisms?”

### 3.1 Telepresence art

The concept of telepresence, from the 1980s onwards, has been an inspiration, not only for researchers and designers, but also for artists. A pioneering project was the Hole in Space work in 1980 by Kit Galloway and Shari Rabinowitz<sup>103</sup>, presenting a real-time audio / video connection between Century City in Los Angeles and Lincoln Centre in New York City. The installation allowed passers-by in the public space to observe, but also to talk to people at the other end (see Fig. 16). This attracted a lot of attention, and in retrospect, can be seen as disruptive:

“Galloway and Rabinowitz did not draw on the dominant model of distraction prevalent in transient spaces. Rather, they produce an interruption, or a rupture and a new model for the interrelationship between television, its new space, and audience avant la lettre.” (ibid.)



**Figure 16: Galloway and Rabinowitz: the ‘Hole in Space’ project.**

Galloway and Rabinowitz arguably created the first example of media spaces (see section 3.4), where two or more spaces are constantly connected by a video / audio link allowing all kinds of formal and informal communication.

An early example of a haptic telepresence project, combining TUI with telepresence<sup>104</sup>, is particularly relevant. In 1986, artist and scientist Norman White, together with artist Doug Back, designed a telepresence installation called Telephonic Arm Wrestling<sup>105</sup>. In this installation two robotic arms, with a force feedback system, connected with a datalink on either side of a telephone line, facilitated an arm wrestling competition over different locations<sup>106</sup> (see Fig. 17). One has to bear in mind that this (functioning) artwork at the time was an achievement, given the state of technology at the time. Tech-art historian Eddy Shanken<sup>107</sup>:



**Figure 17: Telephonic Arm Wrestling, a telepresence installation by White and Back.**

“White and Back hacked this piece together in 3 months, quite an achievement.(...) One of the interesting elements is that in those days the latency of the network was significant. This meant that when the network was slow, both parties could simultaneously win but also lose.

And this defeated the whole competition idea of arm wrestling.”

The idea of ‘defeating the competition’ by Edward Shanken is arguably an understatement claiming that the project actually only worked conceptually because it was not possible, with the networks of the time, to really arm wrestle with the contraption. It addresses though the importance of latency for the experience of these systems. Latency of more than 20 milliseconds already distorts the experience of control over distances (see section 2.7.4). This shows that the control of telepresence systems like the telepresence receptionist is only feasible with low latency networking: the intuitiveness, the one-on-one relationship with the output is one of the main conditions for this form of interaction. Low latency networking, fast electronics, have been



available for about 10 years, implying that real, convincing embodied simple interaction over distances, like in conjoint control, is only at the beginning of its lifecycle.

### **3.2 Telepresence and the concept of presence**

Generally used telepresence applications were scarce until the mid-1990s when networked communication became easier to establish because of the introduction of the internet and the availability of easy to program microchips and other off-the-shelf available electronic components.

In the beginning of the 1990s, Bill Buxton<sup>108</sup> approaches telepresence from the angle of computer supported cooperative work (CSCW, see section 3.4): as a tool to communicate and collaborate over distances. He stresses the importance of the integration of the different technologies involved to enhance the experience. He argues Videodraw<sup>109</sup> and its successor Videowhiteboard<sup>110</sup>, two telepresence applications that facilitate collaborative drawing over distances for collaborative ideation processes, are outstanding examples of telepresence tools for collaboration.

Haans et al. introduce a theoretical framework<sup>111</sup> and IJsselsteijn<sup>112, 113</sup> provides a brief historical overview of telepresence. His description of telepresence emphasizes the notion of presence: the experience of the user interacting with a system:

“It refers to the phenomenon that a human operator develops a sense of being physically present at a remote location through interaction with the system’s human interface, that is, through the user’s actions and the subsequent perceptual feedback he/she receives via the appropriate teleoperation technology.”

IJsselsteijn refers to early film scholar Bazin<sup>114</sup> in his effort of describing a reciprocal relationship between actor and audience, as in theatre, and a semi reciprocity in for instance television:

“The spectator sees without being seen. There is no return flow....Nevertheless, this state of not being present is not truly an absence. The television actor has a sense of the millions of ears and eyes virtually present and represented by the electronic camera.”

IJsselsteijn furthermore mentions Goffman<sup>115</sup>, a sociologist and writer who described the 'dramaturgy of everyday life' and in 1963 introduces the term 'co-presence', where persons are mutually aware of each other's presence, this having repercussions for their behaviour. In relation to this IJsselsteijn concludes:

"This mutual and recursive awareness has a range of consequences on how individuals present themselves to others."

IJsselsteijn also remarks that Goffman's co-presence only refers to real life relations and not to mediated communication. The concept of 'presence' in relation to mediated communication has been studied in the context of 'virtual environments'. Sheriden<sup>116</sup> distinguishes between telepresence and virtual presence, telepresence being the "sense of being physically present with virtual object(s) at the remote teleoperator site" and virtual presence "the sense of being physically present with visual, auditory or force displays generated by a computer". He presents three "measurable physical variables which determine telepresence and virtual presence":

- The extent of sensory information (the transmitted bits of information concerning a salient variable to appropriate sensors of the observer).
- The control of the relationship that sensors have to environment (the ability of the observer to modify his viewpoint for visual parallax or visual field, or to reposition his head to modify binaural hearing, or ability to perform haptic search).
- The ability to modify physical environment (the extent of motor control to actually change objects in the environment or their relation to one another)." (ibid.)

In short, Sheriden proposes the variables: input, perspective and control. In relation to our project these variables provided workable, practical concepts for the design process of the telepresence receptionist where we aimed to design it so that the extent of sensory information is limited to the appropriate 'sensors of the observer' and the control of the visual parallax were actual metrics.

Buxton<sup>108</sup> argues that videoconferencing and telepresence are generalizations for a number of technologies, applications and functionalities that all use a direct video link between two separate locations allowing synchronous communication:

“To speak of ‘videoconferencing’ or ‘telepresence’ is analogous to speaking about ‘buildings’. While having some value, the grain of analysis is too coarse to foster an understanding of what goes on ‘inside’.”

He concludes:

“..we have argued that effective telepresence depends on quality sharing of both person and task space. Through this, the interaction breaks out of being like watching TV, into a direct engagement of the participants. They meet each other, not the system.”

This argument was an inspiration for the design of the system I built: the ambition was to create a design that is actually disappearing, to allow the users, the operator of the system and the visitor, to communicate as directly as possible with no interference of the system.

### **3.2.1 The concept of presence and embodiment**

Although in telepresence there is certainly a range of applications that is based on an intrinsic urge to feel connected, to be ‘present’, when communicating with a person ‘on the other end’ there is, arguably, also a certain domain of applications where embodiment is more dominant in the interaction than the illusion of presence. Intuitive use, induced by an embodied design, does not necessarily depend on the illusion of being present at the location where the task is performed. Users can be aware of their position and still control the application in an intuitive way. Like motorists in most cases do not feel like they are part of their car when driving it but still act like it is part of their bodies, a user of a telepresence application can operate the interface intuitively, while not ‘feeling present’ at the other end. In this perspective, when users get familiarized with an application that allows them to perform tasks in a remote location, this idea of presence is highly context dependent. Some applications require a certain illusion of ‘being there’, in others it is of less importance. Related to this, there is the issue that, after prolonged use, users change their attitude towards an application. Although a system might suggest a certain ‘presence’ at the other end, the user controls the application, generally without the sensation of presence. Users of technology adapt to their technological environment<sup>117</sup>. Like the spectators of the very early film of the arriving train<sup>118</sup> of the Lumière brothers would be terrified the first time the train ‘drives into’ the movie theatre, the second time the film was played would be experienced as less spectacular

whereas at the tenth time the experience for the spectators would arguably have been seen as 'normal'<sup>119</sup>. They would be aware that they are spectators, watching a film that is recorded earlier, rather than having the illusion to be present at the train station where the train is about to arrive.

Still, the suggestion of navigating through a remote space, for instance with a telepresence robot, but also in 3D computer games, has a certain physical impact. When I play computer games, my body oftentimes 'moves with the action'<sup>120</sup>. This behaviour is not functional, is not required for more accurate action (shooting more bad guys) but it certainly adds to the experience.

### **3.3 Telepresence applications**

Despite telepresence not being synonymous with video conferencing, many commercial telepresence applications, especially since the availability of video chat platforms like Skype<sup>121</sup>, are generally equipped with a direct audio / video link. The audio / video connections are literally the eyes and ears of the system, allowing not only monitoring the other end, but also for the stimuli that support the experience of presence. But, as mentioned, telepresence can also make use of other functionalities, like robotics (telepresence robots, haptic feedback in for instance robotic arms in telesurgery), or tangible interfaces (camera / screen control in our system). Apart from in the arts, real life applications for telepresence have been developed for a number of domains. Examples include:

- Collaborative applications: combining videoconferencing meetings, a system that allows having meetings over an audio / video link from different locations, with added functionalities like attention protocols and / or possibilities to show presentations. The reception of videoconferencing for collaboration when the technology was introduced was ambiguous, due to failing technology sometimes even negative<sup>122</sup>, in the last decades, remote collaboration has become a much used tool for, for instance, educational purposes<sup>123</sup>.
- Challenged children: the use of telepresence tools like the Webchair<sup>124</sup> to attend class from a safe space or home<sup>125</sup>. Webchair and similar technologies feature a panning, tilting and zooming camera function, enabling the children to 'look around' in class.

- Telepresence robots: generally speaking and with exceptions, remote controlled - over the internet or dedicated networks - moving robotics, carrying a tablet at face height, showing the person who controls the robot on the screen, enabling her or him to address the other end by an audio / video connection. Telepresence robots can be used to for instance attend meetings or conferences from afar but also for monitoring purposes<sup>126</sup>.
- Telesurgery: surgery over distance by means of telepresence has been, over the past 10 years, what is called an 'emerging' technology<sup>127</sup>. Although still in an experimental phase, telesurgery promises a number of benefits. In the event of a shortage of surgeons, Virtual Interactive Presence (VIP) systems could replace an actual surgeon or provide assistance, for instance by an experienced surgeon in a different location. Note: this field differs from robotic surgery, that is done by a specialized surgery robot, controlled by a surgeon, at the same location. Telesurgery offers the possibility to operate from a different location.
- Music: collaborative projects where musicians compose music together over the internet are quite common, since the introduction of collaborative composing programming environment (with GUI) Supercollider<sup>128</sup>. But also the actual playing together using an audio link over distances<sup>129</sup> is possible by using low latency audio links.
- Haptic telepresence interaction: there is a wealth of applications communicating emotional stimuli over distances. In 1997 Scott Brave presented the InTouch at CHI<sup>130</sup>, a prototype that exchanged haptic stimuli for the fingers. There are applications that for instance make people aware of the heartbeat of a loved one at a remote location, like the iFeel<sup>131</sup>, or of breathing like the BreathingFrame<sup>132</sup>. Recently, haptics in a telepresence context are studied in for instance tele surgery applications<sup>133</sup>. The 5G network technology that is being introduced in many places in the world in 2020, facilitates much lower latency levels on mobile devices than the 4G mobile data network it replaces. This will open the door for haptic telepresence applications designed with for instance conjoint control approach<sup>134</sup>.

Contemporary commercial telepresence applications include the BeamPro 2<sup>135</sup> of Sutable Tech, an advanced telepresence robot for high end contexts. Apart from this, many platforms offer videoconferencing over the internet (audio / video link), with varied added functionalities.

### **3.3.1 Telepresence receptionists: from EuroPARC to 3D technology**

I am not the first to design a telepresence application for a reception desk. An early report, from 1987, of applying an audio / video connection to a reception desk comes from EuroPARCs' media spaces. This was a permanent audio / video connection between the assistant of the director and the receptionist of the department that was described as one of the most intensively used functionalities (see section 3.4.1). Furthermore, there are receptionist functionalities on the market where a piece of software provides a receptionist functionality usually based on tablets<sup>136</sup> on which the visitor can 'log in the building'. In other applications a remotely located 'real' receptionist, like in our application, operates a telepresence screen<sup>137</sup>. Some applications use 3D technology like Telepresence Tech<sup>138</sup>, with rigid screens in 'landscape mode'.

Since the Covid-19 crisis the concept of office space and how to use it is being re-evaluated. Many companies and institutions apply stringent regulations and at the time of writing working from home is still the norm. It is more than likely that the function of a receptionist will be re-assessed and innovated.

## **3.4 Media spaces**

Related to this study is the concept of media spaces, a term used in the field of Computer Supported Cooperative Work. CSCW was initiated in 1984, as a follow up to an international exchange group called Office Automation, focussing on "how people work in groups and organizations and how technology affects that"<sup>139</sup>. CSCW is a multi-disciplinary endeavour, combining the efforts of economists, social psychologists, anthropologists, organizational theorists and educators<sup>140</sup>. Media spaces, one of the subjects of interest, are a direct audio / video connection between two physical spaces facilitating communication over distances. The setup is usually a microphone, loudspeaker, camera and a video screen in both spaces, with interfaces that control a range of functionalities, like shutting off the audio and switching from one location to another.

Media spaces were experimentally used at the Xerox PARC research labs in Palo Alto and Portland Oregon when these departments were, as they put it

“geographically split”<sup>141</sup>. The two locations of PARC’s System Concepts Laboratory (SCL), in 1984, applied video technology to connect “people across distances”. The mission was:

“..to consider interpersonal computing, the logical successor of personal computing which had dominated computing and communications research.”

Apart from early videophone tests by telephone company AT&T, the lab had been inspired by the Hole in Space artwork of video artists Kit Galloway and Shari Rabinowitz (see section 3.1).

The SCL emulated a ‘real’ connected space: sometimes the relationship between the two spaces was casual, and sometimes more intense. At times, the communication was work related, at other times it this was less important and the focus was on more informal communication and sometimes the other end was more or less ignored. At those moments, users did not pay any attention to the screens, but there was the peripheral awareness on both sides that there was a ‘window’ to the other side. Privacy issues were dealt with by either shutting off the microphone or the video camera altogether when required.

An interesting point was the categorization of the mediated activities of the PARC researchers: they mention that the awareness function of the video connection, the peripheral quality, the mere idea that there was activity at the other end, as one of its main functions:

“Being aware of such activities required no response; it provided an overview of who was around and what was happening (and afforded the possibility of joining in)”<sup>141</sup>.

Other activities noted as valuable were chance encounters, the haphazard meeting of a colleague and starting conversations that would have otherwise not been possible. During the media spaces experiment the PARC researchers also logged activities like:

- Locating colleagues.
- Personal and group conversations.
- The playing of recorded videos.
- Project support.
- Presentations.
- Social activities –like connected parties.

The connection, apart from when it was shut off for privacy reasons, was always open. Bly et al.<sup>141</sup> define three different points of reference with respect to the language that describes media spaces:

- Spatial, what kind of space is described; hallways, conference rooms etc..
- Object, what is in the spaces, what objects can be recognized.
- Figurative, people: look at the screen and say: 'there is Jim!'

PARC researchers pinpoint the most important contribution of Media Spaces at the peripheral, the awareness that "there is somebody, or multiple bodies, at the other end"

Wendy Mackay<sup>142</sup> argues:

"However, research in computer-supported cooperative work has tried to emphasize the user, with models based on Shared Workspaces (to support shared work on a common task), Coordinated Communication (to support structured communication to serve a specified purpose), and Informal Interaction (to support informal, unplanned and unstructured interactions). Although media spaces can incorporate all three, they emphasize informal communication, providing people working together at a distance with interactions that they take for granted when they are colocated."

In 1990 Bellcore, the Bell Communications Research lab, presented the VideoWindow<sup>143</sup> project. The set-up, two locations connected by a large screen and loudspeakers, cameras and microphones was, again, relatively simple. The system was designed to facilitate and stimulate informal communication. Interestingly, during the experiment, substantial hesitations in the communication of the people between the two locations were observed. One of the outcomes of the experiment was that people were less likely to start a conversation via the system, than in a face to face situation. The authors did not investigate the reasons for this but assume that one reason might be that there is no affirmative signal in the system that shows that the subject that sees a person at the other side, is actually noticed by that person. In other words, the test persons regarded the screens as television sets, rather than a video chat window.



### 3.4.1 EuroPARC's RAVE

EuroPARC<sup>144</sup> was a research facility established in 1987 in Cambridge, England also by Rank Xerox Ltd. It invested in research aimed at how collaboration within groups can be supported by technology. In one of their buildings, called Ravenport, an elaborate media spaces set-up was implemented that allowed extensive study of interfaces, systems and concepts. The system was called RAVE<sup>145</sup>: Ravenport Audio Visual Environment and the ambition was to augment, support work- and social interaction.

The system was made of off-the-shelf components and designed for different modalities of communication. To facilitate this, spaces for different functionalities were designed, each with an individual purpose like 'the commons', for more informal exchange and the 'conference room', as a laboratory for the study of meetings. Interesting for our study is that RAVE consisted of several cameras with an interface with a video switch. When given permission, the user could open the audio / video connection. Some of the longest running media spaces were the reception desk and the personal assistant to the director, who had a permanent 'office share' facility with a *pedal* to open up the audio connection. The RAVE interface evolved over time, functionalities were added and removed, and also the platforms it was built on changed. One of its features was the flexibility of the system:

"Tailorability was particularly important, allowing users to explore different kinds of connectivity and express individual differences, ensuring everyone a choice in how they were represented within the media space."<sup>142</sup>

The RAVE system, that was used by an extensive number of office workers, raised several questions concerning ethics and privacy<sup>146</sup>. A system that allows audio / video communication, like in the telepresence receptionist, but in the case of RAVE over a network with 35 'nodes', has a built in risk of security and privacy issues. Paul Dourish addresses this issue and introduces a tailormade solution for the RAVE system:

"The result is a software component called "Godard" (Dourish, 1991) which provides inhabitants of the media space with flexible control over the degree of access they grant to others, and dynamic information on connections and connectivity."(ibid.)

The Godard behaves differently in different circumstances and is a technological tool. Dourish notwithstanding argues the cultural component in the addressing of security and privacy issues is at least as important. Users have to be aware of the sensitivity of the images and sounds they can receive and / or send and act accordingly. The set-up of the receptionist and the office of the director has similarities with the telepresence receptionist. Moreover, the participatory design process of the system, the longitude of the study, have analogies with our study. Another resemblance are the privacy issues of the system and how they were addressed. The RAVE applies for instance a pedal to open and close the audio connection in media spaces where this is appropriate (Office spaces), the telepresence receptionist has a LED button that shows the operator is offline and cannot be overheard. This was a fundamental feature. In the field trial, users who reported they appreciated the button and when the LED malfunctioned and it was not possible to see whether or the camera on their end was on line, they stopped using the system.

### **3.5 Media spaces and the telepresence receptionist**

For the design of the telepresence receptionist, the concept of media spaces was one of the inspirations. When designing, the idea was not only that the main focus of the system would be the communication of the receptionist with the visitor but also possibilities for informal communication and the peripheral awareness of the receptionist. Also the modular, off-the shelf approach of RAVE and its focus, in the design on privacy has analogies with the design process of the telepresence receptionist.

### **3.6 The ethics of open audio / video connections in public spaces**

The study of the telepresence receptionist relates to the concepts of media spaces and telepresence, researched before and around the turn of the century. These, relatively early texts on this topic also discussed the privacy issues such a 'window' to another location (see section 3.4.1) implicate. Chapter 4 of this thesis discusses the methods of this study and the ethical repercussions of the field trial.

# 4. Methods and ethics for design and evaluation in a real-world context

## Introduction

My study draws on research through design methods in HCI<sup>147</sup>. I applied a holistic view to my design and based my study methodology partly on *The Reflective Practitioner*<sup>148</sup>, by Donald A. Schön, especially where he argues that many processes in design rely on the intuition of the practitioner. This intuition is the result of an often implicit body of knowledge the practitioner has acquired as a professional. Schön makes the comparison with an accomplished chess player, who does not consider the unlikely possibilities of a next move but only zeroes in on the 'moves that matter':

“Like a chess master who develops a feeling for the constraints and potentials of certain configurations of pieces on the board, Quist seems to have developed a feeling for the kind of conversations which this design situation sets in motion.”

Schön describes the attitude of the reflective practitioner, someone who reflects-in-action as:

“When someone reflects-in-action, he becomes a researcher in the practice context. He is not dependent on the categories of established theory and technique, but constructs a new theory of the unique case. His inquiry is not limited to a deliberation about means which depends on a prior agreement about ends. He does not keep means and ends separate, but defines them interactively as he frames a problematic situation. He does not separate thinking from doing, ratiocinating his way to a decision which he must later convert to action. Because his experimenting is a kind of action, implementation is built into his inquiry.”

Schön's study is critiqued by Gilroy<sup>149</sup>, detecting 'infinite regress' (invalid argumentation) in Schön's train of thought, and incoherency and irrelevance. Newman<sup>150</sup> also critiques Schön's arguments, suggesting that the term

reflection is problematic and therefore proposes using the term 'critical practice' instead of Schön's reflective practitioner.

I nevertheless noticed I adopted this attitude, in particular during the design process, where I went through several iterations, designing and evaluating a number of prototypes, using feedback from various sources, where my main role was that of an interaction designer / researcher and my intuition was part of the decision procedure, ruling out design possibilities that were for instance not feasible. Of course, in reality the scene was not set so clinically. Apart from interaction designer, I was to an extent, limited by my particular skills in these different areas, also 3D designer, engineer, programmer, network engineer, video maker, chief tinkerer and project manager. In all these capacities I asked for feedback and help from professionals.

In the design process, the aim, designing a simple interaction, and the theoretical framework, merged into new theories about the design that were then again tested and developed into a new theoretical approach. It resulted in a cycle of theorizing, evaluating, and again implementing and testing. In the case of the controller it meant I built a number of functionalities, adding and leaving out features until the final result had a relationship with the theoretical basis, but at the same time possessed the qualities that at the start of the process were still not articulated, but as a result of the cycles was the start of a new theory, or concept.

#### **4.1 Field trial**

Field trials have become increasingly common in HCI, and are seen as a valuable addition to the methodology toolkit to evaluate interaction systems. In general, in a field trial, new systems are deployed in a real-world context and a set of users is observed, often documented with an ethnographic methodology. But longer running tests outside of the lab have their challenges. There are more factors that can influence the results than in a controlled environment. Brown et al. <sup>151</sup>, who have looked critically at field trials, identify

- Demand characteristics: users in trials are aiming to 'please' the researchers.

- Lead participants: some participants take it upon themselves to lead the use and the comments on the system..
- Interdependence of methods and results: the researcher is influencing the results by narrowing down the way of questioning.

Kjeldskov et al.<sup>152</sup> argue that field studies are an appropriate tool for HCI research. They remark though that one of the weaknesses of field studies in HCI can be its messiness: complicated data gathering and also a bias with the user group.

The field trial<sup>153</sup> of the telepresence receptionist combined several methods of recording: an ethnography, interviews and questionnaires. The bias of our user group is hard to reflect on. One observation is that it was not a stable factor: over the months the attitude towards the system and the researcher shifted: from initial distrust to more sympathy, although, in my perception, users maintained a critical attitude until the end of the study.

Other factors in my field trial that might have influenced the data are:

- The wear and tear of the system I built: although made to withstand daily use, some parts of the interface wore out and one had to be replaced: the LED button. The feedback of the user set might have been influenced by this.
- Because PROTO was just starting, at the beginning of the user study it was relatively quiet and at the end relatively busy. This also might have influenced the comments from the users.

A positive factor in the field trial was that the user group did not change over the 6 months: no user quit her of his job or changed position.

#### **4.1.1 Working with users**

The user group, although a newly formed team, was a tightly knit community. It took a while to gain the trust of the team: one participant told me afterwards that some of them assumed that I was there to launch a new system and that they would not, ever, see me afterwards<sup>154</sup>. When they were informed of the aim of the study and convinced I was not there to 'spy on them' as one participant put it, they allowed me to become 'part of the furniture' making it possible to observe their daily procedures. The method I applied was to be

present for longer periods of time, observe and engage in conversations about the system and the place it had in their workflow.

#### **4.1.2 Ethnography**

The field trial depended for a large part on the user group working with the final prototype for an extended period of time. Because the study took place in a 'natural' environment, the methodology applied can be seen from the perspective of HCI ethnography: I observed and documented the day-to-day activities of the users. The perspective of ethnography in an HCI context is to approach all activities in a socially dependant context as part of the day-to-day activities of participants<sup>155</sup>.

Due to privacy reasons, it was not possible to record the use of the prototype in its real-world context on video. The data I gathered were observations and conversations with the participants, documented by taking notes and sometimes photos, when it was possible and no visitors were present.

As a result of this strategy, I eventually became a 'usual suspect' in the hallways of PROTO. My presence, and this was something I reflected on regularly, also influenced the social procedures in the office. I noticed, after a while, that although I tried to be as unobtrusive as possible, the quick note taking by me was sometimes interpreted, not directly like spying, but still as a factor to be reckoned with.

I asked the team about this and they confirmed that although there was a relationship of trust, their attitude was slightly different from the moments I was not there. In the course of the project, I started taking notes just after the observations, so as not to disturb the users.

#### **4.1.3 Autoethnography**

Contrasting the ethnography methodology that attempts to build an objective narrative, is the autoethnography approach, where the researcher acknowledges she plays a role in the social construct of the field study and the subjectivity that it accompanies:

"Autoethnography is an ethnographic method in which the fieldworker's experience is investigated together with the experience of other observed social actors."<sup>156</sup>

In my approach, this inevitably played a role but I did experience it as a hazardous activity. Having worked in journalism for a long time, I am used to interpreting and setting up narratives and I know first-hand that these narratives have a tendency to lead their own life. Therefore it makes sense to introduce the narrator in order for the reader to get an idea of the perspective from which the study is written. On the other hand, and this makes it, in my experience, sometimes problematic, when we let in the self, the subjective narrator, everything that is documented can be read from this perspective. In other words, the autoethnographer has to be completely honest and self-critical for the autoethnography to be of any value<sup>157</sup>. This, to be totally frank, made me shy away from some first person stories and maintain a more documentary style. It is hard to assess sincerity, especially when it is your own.

## **4.2 Participatory design**

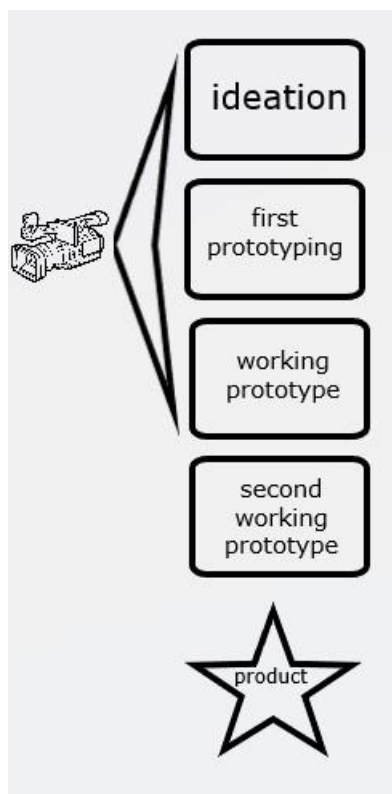
Participatory design was first proposed in Scandinavia when computer systems were introduced into the workplace<sup>158</sup>. The idea was that the balance of power would be disrupted when the management of an organization controlled the nature and goals of computer systems and workers would be left out of that process. This inspired a discourse that first focussed on the level of the workers but later also incorporated the level of management and national politics. The main motivation was to restore balance in the structure and the goals of computer systems in order to motivate all parties to contribute to society by means of computer systems. The political angle was motivated by the argument that computer systems were introduced not to improve workers conditions but solely to control them, boost productivity and profit. The participation of workers in the design of systems would prevent the machines from taking over human employment.

In participatory design there is a relatively large role for the user: the requirements are in general that the participant has a role in the decision making. In this design process and field trial, I took the role of designer and final decision maker. However, the position of the user group, especially in the 'soft implementation phase' could be completely contrary to the intentions or plans of design and still be implemented. As a rule though the final decision making was done by me. This was communicated to the user group.

The role of the experts was slightly different. They provided input and engaged in discussions, sometimes quite detailed, and expected good arguments. This lead to interesting discussions and frequently to unexpected and drastic decisions. Also in this process, the roles of the users and experts that gave input were communicated as clearly as possible and agreed upon.

#### 4.3 Video as a tool for evaluation in the design process

Video was one of the tools I used to evaluate, but also to communicate ideas in the design process. Jordan et al.<sup>159</sup> suggest in this perspective interaction analysis, that is based on video: recording the interaction and subsequently analyzing the footage. They firstly identify the ethnographic context, make descriptive logs of the video footage and evaluate in group sessions. Video can be stored, replayed and show the difference between what “people say they do and what they actually do” and this proved to be a valuable evaluation tool for my design process. Although Jordan et al. recognize that a video is something different than the real object, they claim video is one of the most objective ways of data collection.



**Figure 18: Stages video prototyping was applied in the design process.**



In the project I used video as a means to make sense of the iterations in two varieties:

- Video prototyping: users act out the functionality of the application for further evaluation.
- Quick decision making: filming the use of the application, while interviewing the users.

I used video mainly in the first three stages of the design process: the ideation phase, and the first two prototyping phases (see Fig. 24). The classical version of the video prototyping, i.e. filming and editing of a video that showed the interaction, was instrumental in the first three phases. The use of video to gather data through user panels was mainly applied to the second iteration. In the second iteration, I used two sets of test panels: 3 inexperienced and 3 experienced users, and asked them to use the tangible interface, combined with the working prototype of the screen. Both panels gave feedback on usability, experience and functionality.

#### **4.4 Comparative study**

This study has a comparative component: after the team had used the bespoke controller in the first two months of the field trial, I switched the controller for a joystick, the generic interface model in this context. The joystick was used for two months. This allowed a comparison of the experience of both interaction models. Comparative studies are not without their inherent issues. Shaer and Hornecker<sup>160</sup> posit the traditional comparative study of TUI is problematic, given that:

“comparative studies focus on objective quantitative measurements such as task completion time, error rate, and memorization time” do not do justice to the fact that TUI often benefit from “high-level interaction qualities such as enjoyment, engagement and legibility of actions”.

They propose field studies as an alternative evaluation method:

“Several recent studies take a different evaluation approach by taking place in the field. Rather than focussing on traditional performance measurements, these studies measure higher-level interaction qualities such as legibility of actions, user engagement, and collaboration. Unfortunately, field studies of TUIs are still rather rare.”

Nevertheless, I wanted to assess specifically the user experience of a bespoke controller, towards the generic control model in this genre of applications. I observed the community of users using both interfaces respectively.

After this period, I interviewed the group and asked them to fill in a Likert scale questionnaire with statements they could respond to varying from fully agree to fully disagree, asking them about their experience with both interfaces.

#### **4.5 Ethics in the design process and field trial**

The ethical risk assessment for this study focussed largely on the collaborative process with the users who provided feedback during the design process and the user group during the field trial at the PROTO centre for emerging technologies and the storage of the data. For the ethical assessment as such it was important that an open attitude towards ethical issues was maintained. An early example of risk assessment in a similar set-up is the RAVE at EuroPARC, where ethics were one of the main considerations when installing the system<sup>145</sup>. Our study combined a number of elements with potential ethical issues. The concerns were:

- data storage
- recording of video footage
- anonymity of users in field trial

The data storage was divided in

- digital data
- written data

The sensitive digital data comprised the notes and summaries of the interviews with users, recordings of the interviews with users and notes of observations. The written data consisted of filled in printed questionnaires and written notes.

##### **4.5.1 Data storage**

Written data, on paper, was kept in files and subsequently stored appropriately in a locked drawer, at Northumbria University. Unnecessary notes have been destroyed. Digital data was kept on an offline, password protected hard drive.

The video stream of the telepresence receptionist ran over a dedicated line of the Local Area Network (LAN), with its own server (a NUC computer, mounted on the back of the telepresence screen). The system is password protected and did not have software installed to record any of the data.

For the user study, this implied that the use of the system had to be logged by hand. Users were not asked to log the use of the system themselves. All data of interviews and questionnaires were stored on a separate hard drive that was exclusively connected to one computer when it was disconnected from the internet. Backups were kept on a separate hard drive, without automatic back up software.

#### **4.5.2 User group**

The user group that collaborated and provided feedback gave explicitly written permission for the use of their input by signing a consent form. In the course of the study no user left the team or was introduced to the team. No (meta-) data were recorded by the system itself of their use. The sets of interviews with the user group were recorded with an unconnected smartphone and stored on a hard drive.

The user group was monitored by the researcher. The notes of these sessions were used as a basis for summaries and afterwards destroyed. The summaries were kept appropriately at Northumbria University.

Over the course of the study a professional relationship with the user group developed. When the system failed, users would send an email to signal this. The users were asked to reflect openly on the use of the system. Emails and notes with this content were anonymized. The ethics of privacy and data protection were regularly discussed with the user group to create awareness on this topic and an open culture where security breaches would be reported.

#### **4.5.3 Management of PROTO**

The boundaries of the study and data gathering were discussed with the PROTO management. They explicitly gave permission for the study. They allowed to interview the team anonymously but gave no permission to interview or record visitors of the reception areas in any way. Over the course

of the study, there were regular conversations with the management about the study and the role of the users.

#### **4.5.4 Test group**

Participants of the non-professional test group that tested the system during the design process gave written permission. The test group that tested the final telepresence receptionist signed consent forms and filled in printed questionnaires that were anonymized and stored appropriately before processing. All participants are anonymized when quoted in the study.

#### **4.5.5 Copyright**

Most pictures and charts in this thesis are taken or made by Sam Nemeth. For the other pictures either the author gave permission, are in the public domain or licenced under Creative Commons. When the latter is the case, the holder of the copyright is mentioned in the list of figures and charts, as required by the Creative Commons licence.

#### **4.6.6 Ethics and video**

Mackay et al. provide a brief overview for the use of video in the design process that fitted our field study. *Ethics Lies and Videotape*<sup>161</sup> advocates the ethical use of video in the design process (especially towards users / actors who are subjects of the evaluation). Furthermore Mackay identifies the inappropriate use of video towards the audience, in academic settings often a conference. In these circumstances, inappropriate material can be shown, for instance showing very private moments of test persons without prior warning. Another perspective on ethics and video is the use of video techniques, like editing, to influence the recorded material. Mackay reflected on the use of video in 1995, when digital video was still in its infancy. Particularly from 2015 onwards, video technology became accessible that can completely alter the meaning of recordings, generally called 'deep fakes'. This technology compromises the use of video for research purposes. Researchers should be wary of any use of video since all 'video evidence' can be manipulated.

#### **4.5.7 Addressing privacy issues in the design**

In the design phase, the issues of privacy were frequently assessed by experts and users. One of the design decisions that was influenced by these arguments was the implementation of a dedicated server on the back of the

telepresence receptionist for the video stream and data exchange between the two screen of the system, using the Local Area Network, rather than the internet. This had the advantage that the quality of the data exchange was excellent, not having to run our video- and data stream over the internet. It also had some repercussions for the security of the data: access to the data exchange via the internet was more difficult.

Another design decision related to privacy was the design of the red LED button that made it possible to instantly shut down or open the audio / video connection, so the operator could be sure no personal conversations could be overheard.

#### **4.5.8 Possible threats**

We estimated that the most probable threat to the safety of the system and the study was the use of audio and audio equipment in a semi-public space. One camera of the system was pointed towards the entrance of PROTO from the inside. A double door in the reception area obstructs the view to the exterior from that angle. The system did not record and store video material.

A possible way to compromise the system would be from the inside, a recording app can potentially be physically (via a usb cable) installed and later physically, via a cable (no Wi-Fi on the system) stored on storage equipment. The system was regularly checked for additional (new) software or changes in the software.

Recognizable Images of the participants have been used with their written permission. Two videos were made with two persons from the test group. Again they gave their permission for the use of the video for academic purposes. PROTO has a security system with cameras, all persons in the building can potentially be seen on video and / or recorded by that system.

#### **4.5.9 The ethics and societal repercussions of the telepresence receptionist**

The concept of the telepresence receptionist, a remotely controlled application to operate a reception desk in an office building, in itself calls for a more in depth ethical scrutiny. One of the issues on a societal level could be that the application can replace workers and therefore disrupt the labour market. Although the telepresence receptionist is by no means a 'robot', in the sense

of an autonomously operating piece of technology, but in a more developed stage, a more advanced version of the telepresence receptionist can potentially manage several reception desks from one location.

There is an ongoing development, specifically in the industrialized world, where for example the function of a teller at supermarkets is being replaced by the customer who scans the products. This is not appreciated by all customers and has disadvantages. Analogous to this, visitors in buildings that are not very frequently visited and in low risk environments, are asked to enter their name on a connected tablet that can also partly replace the services of a receptionist: provide directions and announce the visitor at the desired location.

The telepresence receptionist is designed for a context where the service of a 'real' receptionist is appropriate but not feasible. The reasons for this can be for instance cost effectiveness, health hazards or when a team is temporarily unstaffed. The telepresence receptionist is designed as a way to provide the customer service of a real receptionist in situations where the service of a real receptionist is difficult to realize.

On the other hand there is no doubt that the use of the system and similar technologies, can have repercussions on employment: when applied in a context where it completely replaces a 'real' receptionist, this potentially will lead to fewer receptionists being employed. This was also discussed with the participants in the study. They acknowledged the system was an appropriate tool but also that they had their initial doubts about supporting a technology that will eventually take their jobs. The fact that this is a telepresence application that still needs a 'real' receptionist, was an argument that convinced them to participate. Moreover, in the current Covid-19 circumstances, the telepresence receptionist can potentially save jobs: receptionists can operate a reception design without the risk of contamination.

# 5. Conjoint Control

## Introduction

This study proposes a new concept, a user-centred, collaborative approach for the design of simple embodied interaction for computer systems with a limited range of functionalities. I have called this approach ‘conjoint control’.

The literature review for this study discusses a number of concepts in HCI from the last four decades that inspired the approach of conjoint control, in particular alternative approaches for the WIMP, the Windows Icons Menus and Pointer that is still generally in use. An early concept, ubiquitous computing, introduced by Mark Weiser<sup>32</sup> (see section 2.2.1), argues that computers should “disappear from sight”, they become a part of the environment. From a later date, the concept of calm computing<sup>37</sup> (see section 2.2.2), by the same author, advocates an approach that allows an intuitive shift of the attention of the user: from the centre, to the periphery. When an interaction is appropriate, it moves to the centre, when it is not, it shifts to the background. These ideas are mentioned as foundations for tangible user interfaces<sup>1</sup>, an influential paradigm, that has also been one of the theoretical cornerstones of this study. Tangible user interfaces aspired to bridge the gap between the screen based interfaces and the world around them, coupling humans, computers and objects, and the environment.

Another, more recent approach conjoint control relates to is somaesthetic design. Described in *Designing with the Body*, by Kristina Höök<sup>77</sup>, arguing for the incorporation of our bodily experiences in design and for ‘calmness’, much like the calmness in calm computing<sup>37</sup>: users should not be inundated with functionalities and their control. A system that performs a limited set of functions very well, is to be preferred over a platform that offers a range of functionalities but all of them controlled by a complex, not intuitive, interface, for instance the GUI on a smartphone. Simplicity is a value in itself and is one of the elementary qualities of any interaction.

A more overarching concept, by no means only reserved for HCI but still a relevant building block of the approach of conjoint control, is embodiment. Embodiment can be interpreted in many ways<sup>84</sup> (see section 2.7) and I adopted the broad interpretation of Paul Dourish, who describes embodiment in interactive systems as the quality of a system that is part of the environment, acknowledging the context, the people and its social structures. This perspective on embodiment correlates with the user-centred approach of conjoint control.

An early example of a flexible development cycle of similar interactive systems was the RAVE interface, for the EuroPARC research lab in Cambridge<sup>145</sup> (see section 3.4.1). This was a video conferencing application that was built in a modular way, from off-the-shelf parts. This allowed tailorability: the system and its interaction could be adapted to its users, even when the system was already deployed. This tailorability, the ambition to design a system that is flexible, was in the years it was first explored in EuroPARC relatively difficult to realize. In the last decades these technologies have become more accessible, because of the flourishing maker culture, a worldwide network of tinkerers, programmers, designers. This network facilitates the small scale design and building of bespoke applications. The approach of conjoint control, relates to this rich culture and also ‘invites’ the user into the process. It is possible to get support from ‘maker’ communities (see section 5.3), even worldwide, to get input from experts. Furthermore, in these processes, users can provide feedback and also directly influence the design process, adapt the design, facilitated by the flexible design process.

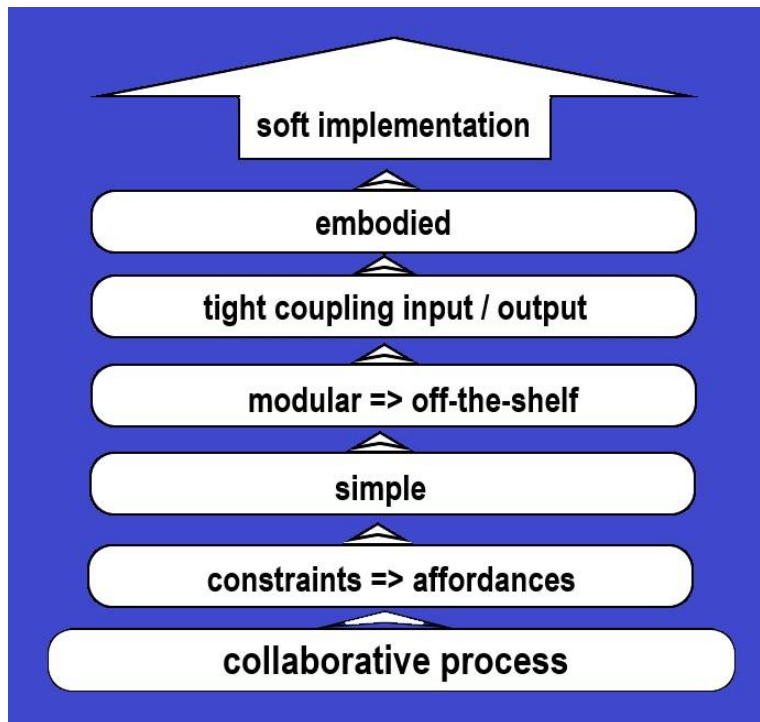
## **5.1 Features of conjoint control**

Conjoint control is an approach that features (see Fig. 19):

- A collaborative process: input from experts and users.
- A relatively small bandwidth between constraints and affordances: the design points at its use and the ways to interact are limited.
- Simplicity: the control has a limited amount of well-defined functions.
- Modular / off-the-shelf parts: tailorable design process.
- Tight coupling of the in- and output: one-on-one relationship between controller and the object it controls.



- Embodiment: relates to the space, the people, the social and organisational environment and the direct interaction.
- Soft implementation: prolonged deployment where the user can familiarize herself with the controller and give input.



**Figure 19: Conjoint control.**

### **5.1.1 The collaborative process in the conjoint control approach**

The design of digital systems is as a rule complicated and requires, to start in the 'technical department' at least a number of specialists: for instance experts in 3D printing, programmers and experts in microelectronics. Also the feedback from users, especially about the experience of a system, is part of a generic design process. What makes the collaborative process of conjoint control stand out in this respect is that it draws on several sources of knowledge, apart from experts in the field, also from the maker culture and open source software communities.

This results in a design cycle where users and experts are asked for input for every iteration of a prototype (see chapter 6). The design is generally built with the more practical contributions from the maker culture and scripts adapted or copied from the open source software communities.

I am aware that in a commercial setting an extensive process like this, using non-commercial structures like maker cultures and open source communities, may not be a realistic option. But I still argue that for a certain genre of custom made applications, this collaborative method, with input and assistance from various sources might be a worthwhile track to explore.

Furthermore, it is important to keep a balance between the ideas and plans of the design and user input, as it is also important to keep a balance between input of experts in the technical part of a system and the skills of the designer<sup>162</sup>. I compare the role of a designer with the role of a film director: controlling all processes, having sometimes limited knowledge of all disciplines. In a conjoint control approach, a designer needs to be aware of the nitty gritty of the system in development and at the same time, have a helicopter perspective of the project in its entirety.

### **5.1.2 Constraints and affordances in conjoint control**

Because conjoint control is inherently an approach to design a simple object that controls a system with a limited amount of functions, the design of the interaction needs to be simple as well. The user has few possibilities to interact and there are also a few options for feedback. This means the interaction design is rudimentary, almost to the bare minimum.

Because of this limited number of functions, applying the conjoint control approach means constraining the design<sup>8</sup>. Simple objects that are generally the object of the conjoint control approach, in general afford only a restricted array of interactions. The feedback ideally is inherent to the controller and can be supported by sound<sup>64</sup>. This implies that there is generally little bandwidth between the constraints, the limitations and the affordances, the possibilities of interaction.

This process is not always without its issues. To achieve a balance, between simplicity, interaction models, aesthetics and the affordances of the interaction design can prove to be challenging. The use of off-the-shelf components limits the choice even further.

### **5.1.3 A limited amount of functions**

Conjoint control is an aid to designing simple systems. The approach is intended for applications with a limited array of functions: systems that perform one task in an outstanding way rather than various tasks in a mediocre way. This implies that during the design process, the amount of functionalities of the design are generally scaled back. The idea is to design a system that does not overburden the user with choices but instead provides the experience of 'being in control', rather than being at a loss.

### **5.1.4 Embodiment**

Embodiment (see section 2.7), the role that our bodily abilities play in the experience of interfaces but also the way the system is positioned in the environment and the people and social structures in it, is a defining factor the approach of conjoint control. As mentioned in section 3.2.1, I argue that direct embodiment of the controller in conjoint control is not so much related to the experience of feeling present, but more so of feeling 'in control', like the motorist who feels he is 'part of his automobile' and therefore controls it intuitively. Embodiment in conjoint control acknowledges that embodied interaction is taking place in an environment, a space, where the people in it have their relationships with the design and with each other.

### **5.1.5 Modular / off-the-shelf components**

The design approach in conjoint control is inherently modular, making it less complicated to use input from various sources and implement it during the design process. The use of off-the-shelf components allows flexibility as opposed to a design cycle where the system is designed and built with custom-made parts.

During the user-centred design cycles, this tailorability<sup>142</sup> facilitates an open attitude towards the users. Adaptions can be made until the last moment. Furthermore, the advantages of off-the-shelf components are the cost effectiveness and the fact that the design process is easier to reproduce, also by third parties.

### **5.1.6 Tight coupling of input and output**

One of elements of the conjoint control approach is the direct relationship between the manipulation of the tangible controller and the result of that

manipulation. The interaction should be clear, non-ambiguous and directly communicated to the user: the controller shows the status of the system.

In GUI based systems, where the mouse is used to manipulate a pointer, as input device, the mouse has no absolute value. When lifted, and put down again, the pointer on the screen is at the same position while the physical mouse can be anywhere else on the table. When a joystick, used to move a for instance a game persona forward, stops the game persona, the joystick flips back to the position in the middle, the neutral position. In both systems the controller itself does not provide any feedback about the status of the system. In the conjoint control approach however, the user gets at least part of the feedback from the status of the controller.

#### **5.1.7 Soft implementation**

One of the elementary features of conjoint control is that in this approach a system is implemented and introduced to the end users in a relatively long, inherently slow, process. The system is set up near the environment where it is supposed to function in a later phase, but in a safe space where users can test the system, in private. Users are allowed a playful period in which they can get accustomed to the interaction. They are also asked for input, about the aesthetics, the functionality and the interaction in workshops and interviews.

In this phase, last minute adjustments are made to the system. Because the design approach emphasizes tailorability<sup>142</sup>, it is relatively easy to adapt the design to the feedback of the end users in this phase. This phase potentially induces a high acceptance rate of the system, because the end users experience the system as theirs, having had influence in the final design. I have called this process 'soft implementation', indicating a safe period, without the strain of the workload, where users are stimulated to get acquainted with the system in a pleasant, playful way.

## **5.2 User contexts for conjoint control**

Conjoint control is not a solution for all use contexts. It is the exception. Many systems can be successfully designed with more generic interaction models. By nature small scale, the approach of conjoint control is not developed to be

industrially reproduced nor does it need to be. With the availability of cheap microcontrollers and 3D printing (see section 5.3), the design and production of bespoke control of systems is more feasible than ever before.

The conjoint control approach is appropriate in contexts like health, where a patient with an individual range of disabilities can be provided with a highly personal application, to, for instance, use a video phone. The interaction system of a smartphone is often not suitable for the motor skills of patients. To control a phone system by pushing a controller with an elbow can mean the difference between isolation and being able to communicate with friends and family.

Another context where the features of conjoint control make sense is the remote control of robotics or telepresence applications. These applications rely on precise interaction and are sometimes frequently used. This control can be a strain on the muscles and nerve system of the user. A bespoke system that acknowledges this and can be adapted to the needs and wishes of the user, can make the interaction more fun and healthy<sup>163</sup>.

Conjoint control is one of the stepping stones in the empowerment of users to design their personal interaction models. In a society that depends on technology, the possibility to adapt the interaction with technology to the individual skills and preferences of the users can contribute to the inclusiveness of interactive systems.

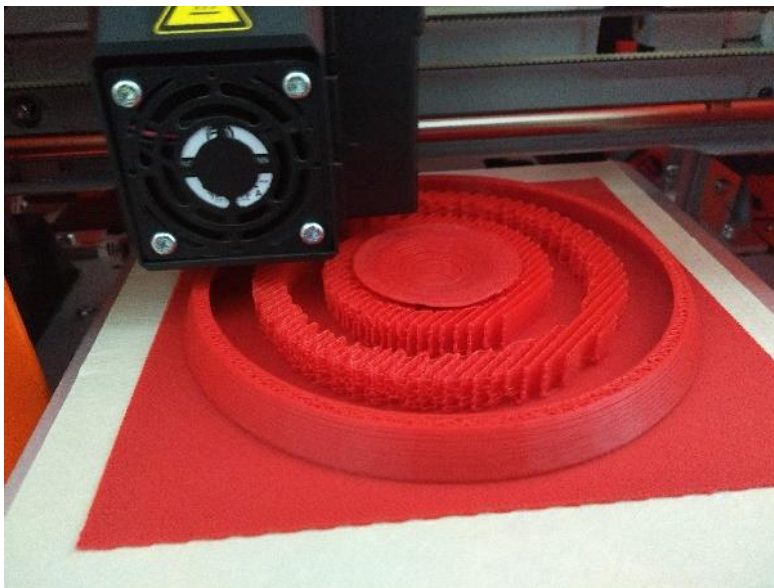
### **5.3 Conjoint control and maker culture**

As mentioned, an opportunity for the approach of conjoint control, apart from commercial engineering companies, is the rich culture of developers, tinkerers



**Figure 21: Newcastle Maker Faire 2017.**

or other specialists who invest time and effort to teach themselves and others to build and program electronics. These communities, the maker spaces, or FabLabs have been sprouting all over the industrialized world, with the aim of empowering individuals to make their own electronic appliances (see Fig. 21). Electronic developing platforms, like Arduino or Raspberry Pi offer the possibilities to build systems for the specialized use and design of tangible, simple interaction models. Arduinos<sup>164</sup> have been on the market since 2005 and are microcontrollers, rudimentary minicomputers, able to process input signals and autonomously perform tasks. They are relatively easy to program. To help users with the programming, there are communities that exchange scripts (the Arduino language calls them 'sketches') that can make the platform perform a wide variety of simple and more complicated tasks, from switching LEDs on and off according to the input of a sensor to controlling home appliances over WIFI<sup>165</sup>. The Raspberry Pi<sup>166</sup> is a more advanced minicomputer, originally designed in the UK to teach children programming. It has connectors for a keyboard and computer screen and can run operating systems and can also be used as a normal computer with the remark that it is relatively small.



**Figure 22: 3D printing a controller for the telepresence receptionist.**

Both platforms are used for prototyping but also to build bespoke computer systems. Another technology available at maker spaces and frequently used in the design of the telepresence receptionist (see Fig. 22) is 3D printing, the possibility to 'print' in a relatively short time span, a 3D object from a plastic,

usually the bioplastic PLA. Although designed for hobbyists, the use of these platforms requires skills and knowledge.

The maker culture, the network of spaces where communities can be helpful in this context, organize courses in microelectronics and also offer direct help to design and build a bespoke system. Maker spaces<sup>167</sup> also offer facilities for the design and building of custom-made applications for user groups like challenged people.

On the other hand a critical attitude towards maker spaces is appropriate. Maker spaces develop in many cases in a rather closed<sup>168</sup>, gender biased (predominantly male), community, focussing on 'geeky' subjects like the control of drones, rather than projects to stimulate inclusivity or develop systems for challenged people. Nevertheless there is ambition, translated in worldwide efforts, to tackle this issue and to engage in a more inclusive, maker space culture by applying new methodologies and apart from technology also a focus on traditional arts and crafts practices<sup>169</sup>.

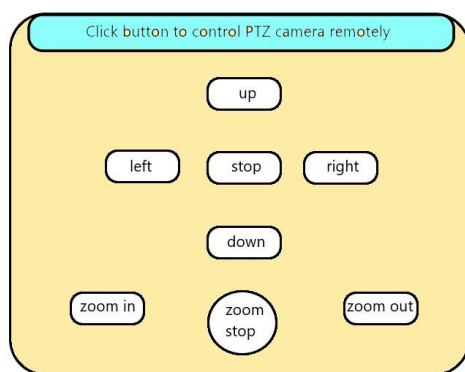
#### **5.4 From conjoint control to the design process**

The concept of conjoint control was one of the results of the design process I applied for the telepresence receptionist. During a period where I developed the system in a number of iterations, I adopted methodologies, approaches, that together were building blocks of the conjoint control approach. In the next chapter I describe this process, that resulted in the system that was the subject of the field trial.

## 6. Design process

### Introduction

I designed, in a collaborative process, a simple controller and a telepresence system for a reception desk. I furthermore studied its use in a field trial. I began by exploring the control of remote cameras. Apart from TV studios, there are other domains where remotely controlled cameras are applied.



**Figure 23: GUI Pan Tilt Zoom function.**

Application domains are for instance the monitoring or remote control of infrastructure like bridges, inspection of hard to access areas with robotic applications like sewers. This growing number of cameras performing vital tasks in many systems is generally controlled by either a GUI (see Fig. 23), or joystick controls (see Fig. 24).



**Figure 24: Control room for remote controlled cranes with joysticks.**

A simple form of camera control is generally applied for telepresence robots. Because this seemed a well-defined context for an in depth user study, I decided to focus on this domain. The telepresence market as mentioned has



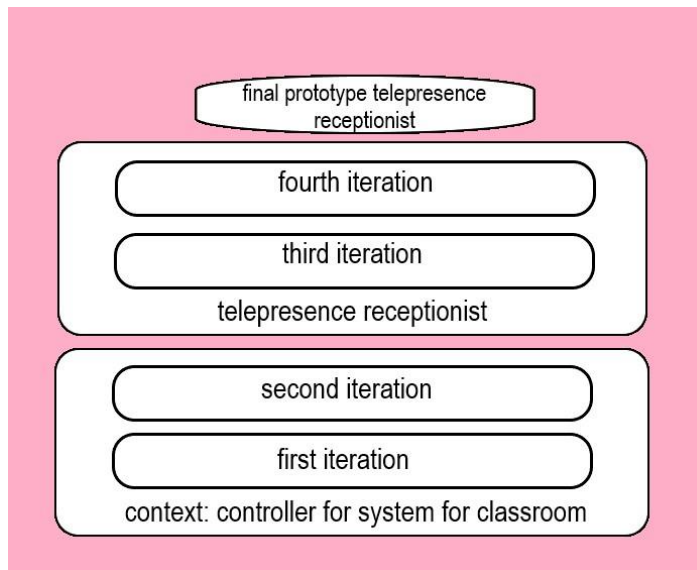
been exponentially growing in the first half of 2020 due to the Covid-19 crisis but this was not the case when this study started.

Together with PhD student Graham Smith<sup>170</sup> at University College Dublin, specializing in telepresence, I first designed and evaluated a controller for a telepresence application in the classroom. Smith developed a number of telepresence robots with on one end a screen that can be manipulated remotely, representing the person who controls the screen at another location, in this case a classroom.



**Figure 25: Building the telepresence screen for the classroom.**

The systems<sup>171</sup>, are designed to allow challenged children to attend classes from home or another safe location. The screen that represents the child in the classroom facilitates 'looking around' by turning, tilting and zooming in and out. The GUI, that typically controls these screens, allows one functionality at the time, a so called time multiplexed interaction<sup>53</sup> and generally suffers from a considerable amount of latency, hampering the telepresence experience<sup>172</sup>,<sup>173</sup>. I decided to explore possibilities for a better, more embodied control of these screens. The purpose was to allow the pupil a more intuitive use of the telepresence screen. I subsequently designed and evaluated a number of controllers to explore the possibilities of conjoint control in this context. No challenged children participated in this study.



**Figure 26: Design process.**

After this study, having designed two iterations of a controller for a telepresence screen, I concluded that studying alternative control of telepresence systems with this direct form of interaction can be a promising direction. It was my aim to do a field study, with a generic user group. The user group for the telepresence system for the classroom did not fit that description. Therefore, I looked for other ways to apply this form of control to telepresence screens for a more generic user group, preferably in a real-world office context, where a system would be used regularly.

I found this context for a field trial at the PROTO centre for emerging technologies in Gateshead, UK. The management asked for a solution for the reception desk for a newly built office. In a collaborative, iterative process, a telepresence system was designed. This finally led to a working prototype, the telepresence receptionist, that was deployed and used for six months. In this chapter I describe first the design process of the first two iterations, a controller for the telepresence screen for the classroom, and then the design of the controller for the telepresence receptionist (see Fig. 26).

## 6.1 First Iteration

In the first mock-up of the interface, designed for the telepresence robot for the classroom, I wanted to make the interaction with the remote screen more intuitive, and because the manipulation of a telepresence screen is often combined with other tasks, very clear. Ideally, the status of the screen and the

accompanying camera (zoomed in / out, tilted up / down and turned left / right) should clearly be indicated by the interface.

I also made a fundamental choice about the metaphorical quality of the interface: the controller has the shape of an eyeball (see Fig. 27). The idea was that this would communicate the 'seeing' aspect of telepresence to the user, as the controller was literally designed to 'look around', by manipulating the telepresence screen with a camera that also represents the user at the other end. There were some initial hesitations, as an eyeball could – also - have a macabre connotation; however, after consulting a panel of three professional video camera operators, I found that this was interpreted, at least by them, as a purely symbolic reference.

In this first mock-up, all functionalities were not integrated in one interface. Because the panning and tilting function and the zooming functionality can be seen as separate functions, I decided to try out a separate slider to control the zoom function of the attached camera. The ball itself controls the pan / tilt function of the screen and also the attached telepresence camera.

I decided on the use of video prototyping. A video was recorded, where two test persons acted out the interaction. I showed these videos to experts as a basis for discussion. Three professional video camera operators were consulted for feedback. These regular users of remote control camera systems thought the ball could be practical to use and provide a direct indication whether the camera is tilted upwards, downwards or panned left or right. The separate zoom function was deemed more problematic. The regular users thought all interaction would ideally be performed with one hand. A space multiplexed interaction that requires the manipulation of two hands for a functionality (looking around) that is experienced as one discrete activity, was considered 'impractical' and a 'nuisance'.

The test persons also provided feedback while recording the video. For example, test person A. said:

“It seems I have to acquire a whole new set of parallel skills, it feels a bit like drumming: two movements simultaneously is rather demanding.”

But the other test person appreciated it:

“Zooming is not something you frequently use: this way you can focus on one task only.”

The first test person said the ball shaped interface was too big for most hands:

“A smaller interface would fit all hands, this larger one only people with big hands”

Evaluating all feedback, it became clear that when using two hands in a situation where the attention of the user has also to be dedicated to a number of other tasks, a ball for panning and tilting and a slider for zooming complicated the interaction needlessly, rather than making it more intuitive.

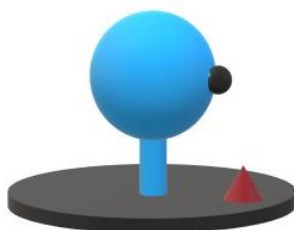
Based on this feedback and the video prototyping evaluation, I decided to integrate the two functions in the next iteration of the interface in one controller. I furthermore concluded that the absolute control, the direct relationship of the interface with the status of the system would still be a viable quality to maintain in the next iteration.



**Figure 27: First mock-up first iteration controller, with a separate zoom slider.**

## 6.2 Second Iteration

In the second iteration, I combined the pan / tilt and zoom functionalities in one controller (see Fig. 28). I concluded from the evaluation of the first iteration, where test subjects enacted the functionality, that it was appreciated that the



**Figure 28: First 3D impression of second iteration.**

fingers of the user could wrap around the ball shaped controller, with the index finger at the front of the ball, so I put a small joystick at the point of the tip of the index finger to act as zoom controller.

The smaller dimensions of the second controller, where the ball has a diameter of 80 mm, as opposed to 92 mm in the first mock-up, also proved to be more practical (see Fig. 29), as users with smaller hands can literally grasp the ball while the controller for the zoom function was in an easily accessible spot. I produced a new video, filming 6 test subjects using the first two controllers. In this set-up, there was a two way telepresence connection. The test persons acted out the use of the controllers. I asked the test persons for feedback while they were using the prototypes.



**Figure 29: Mock-up second iteration.**

Overall the response to the new design was moderately positive in comparison with the first iteration.

One test person said:

“This is better than the other one (first iteration - SN), if only because the ball is not so big. It could be even smaller though, I suppose people with bigger hands can use both big and small, while smaller users, like me, obviously have problems with a ball they cannot wrap their hand around.”

Another test person:

“I like the way you can use it but the design looks too neutral to me.

For me, a special computer interface should be easy to use and have a nice, not too anonymous design.”

Two test persons mentioned that in this design it is unclear how the controller of the zoom function, a small joystick attached on the front end of the ball, should be manipulated and that it does not seem to be an intuitive interaction. The joystick typically flips back to a zero position and doesn't in itself provide feedback, it was also not clear whether or not the joystick should be moved up and down (as was the case) or from left to right. I concluded that the next working version should address this issue. Especially the zoom function can cause confusion as it is hard to judge from the video feedback on the monitor

at the controllers' end whether or not the camera of the telepresence screen is zoomed in or out.

In the final design of the second iteration, I decided to implement a mouse wheel replacing the joystick for the zoom functionality at the same location on the front side of the sphere (see Fig. 30). The mouse wheel is absolute in the sense that it does not flip back to a zero position after manipulating it but reflects directly to the zoom status.



**Figure 30: 3D sketch of final version iteration 2 with wheel for zoom function.**

The final design of the second iteration also features a wider 'stem', to provide the design with more solid basis. I evaluated this design and drew the following conclusions:

- For control of telepresence, the 'stem' of the controller is not practical.
- An even smaller sphere will facilitate all users, also with small hands, it won't bother the users with big hands.
- The mouse wheel for the absolute zoom function is a practical alternative.

### **6.3 The interface as part of a working telepresence system**

After having evaluated the second iteration, an appropriate context was needed to continue the study. The objective was to implement the controller in a real-world situation to evaluate it in situ, with 'real', professional users. In particular I looked for a generic, day-to-day context where the concept of telepresence could be a valuable addition. The studies of the first controllers had indicated that there might be opportunities for simple, straightforward



**Figure 31: 3D sketch of the telepresence receptionist, visitors end.**

control of telepresence screens. Nevertheless, studying a telepresence application where sometimes vulnerable users with a disability are involved, like in the first iterations, was problematic for several reasons. Firstly, the ethical constraints when challenged users are part of a study, especially with collaborative elements, could make the study in reality impossible to execute. Secondly, because the study objective was to look at a day-to-day context, a study involving only challenged children would not cover the desired user group for this study. A telepresence application with a more generic context for a more generic user group would be more appropriate and workable.

A context where I could build a fully functioning prototype was found at the Gateshead City Council. The council owns a series of office buildings, located adjacent to each other on the same street. In this street, the council was about to open a new office. This office, the PROTO Centre for Emergent Technologies, would function as an incubator. Start-ups, small companies, could rent office space there at moderate prices. The council was facing the problem that their resources were too limited to allow the full time manning of the reception desk of PROTO. Based on the earlier prototypes, and 3D sketches, I suggested remotely manning the reception desk from adjacent offices by means of a telepresence system (see Fig. 31). This context, applying simple user scenarios, allowed to study the control of a telepresence screen in detail as part of a complete system.

### **6.3.1 The workplace**

The practical purpose of the system had repercussions for the remaining design process. For this specific situation, a design and structure of an entire system had to be built that could not only withstand daily use, it would also have to cater to the needs and wishes of real users, and ideally also meet the requirements of the management of the PROTO centre. I had a number of conversations with the management and visited the actual reception area, a reception desk where the telepresence receptionist would be functioning. Then I talked to the prospective users of the telepresence receptionist in the reception area. We discussed the visitor experience: how is a visitor welcomed and the services the receptionists provide.

This proved to be instructive. Apart from feedback of potential future users, the processes were observed that were going on at a reception desk. One of the

design challenges was the attention protocol, the way a visitor could attract the attention of the 'real' receptionist at the other end. When visiting the reception desk, I observed that the receptionists used a simple hotel bell (see Fig. 32) to attract their attention when they were temporarily absent. This was an opportunity to implement a one button interface for interaction with the telepresence screen that in its appearance and use already exists in the frame of reference of the visitor. The use of the embedded hotel bell was sustained through all the design cycles and is still present in our final design. Apart from attracting the attention of the receptionist at the other end, we tested a number of other functions for this, in fact, one button interface in the guise of a hotel bell, like booting up the system, starting up another graphic on the telepresence screen if needed.



**Figure 32: The hotel bell and the reception desk during our visit.**

### **6.3.2 User protocols**

Based on the observations, the interviews and the feedback of the PROTO management, four main user protocols were defined that the system should be able to facilitate:

- Generic user protocol, welcoming a visitor: the visitor enters the hallway and encounters the telepresence screen. On the screen there is a text with graphics asking the visitor to ring the bell to attract the attention of the receptionist. The visitor rings the bell tethered to the system on the reception desk that signals the real receptionist that there is a visitor at the other end. With the controller, the receptionist opens up the video connection, he or she is now visible on the telepresence screen at the visitor's end. The receptionist can turn the screen at the other end in an ideal position, to look the visitor in the eye. The visitor and receptionist are able to communicate two-way. The visitor can be welcomed by the receptionist, can ask for information if necessary, and the receptionist can



ask the visitor to either sit down and wait or give directions to the office where the visitor is expected. The receptionist can announce the visitor at one of the offices in the building. If needed, the receptionist can ring the bell again at the visitors end to gain her or his attention. Then the connection can be closed again by the receptionist. On the telepresence screen at the reception desk, the default message for visitors to ring the bell is again visible.

- Monitoring the hallway: a receptionist is able, at all times, to observe the space where the telepresence screen of the telepresence receptionist is installed. He or she can pan the screen and camera thus observing the space when necessary. The receptionist can also attract the attention of a visitor by ringing the bell connected to the telepresence screen in the hallway / reception space he or she is monitoring (works two-way at all times).
- The 'please, wait a moment' screen: it can happen that a receptionist is occupied when a visitor rings the bell to attract the attention of the receptionist. If this happens, the receptionist can change the message on the screen from a 'please ring bell' to 'please bear with us for a minute' message. This is done by pressing the wooden controller once. The receptionist can, being available again for the visitor, open up the video connection and welcome the visitor, as in the first user scenario.
- Using the turning screen to indicate a direction: the receptionist can, after welcoming the visitor, use the turning screen at the visitors end to indicate a direction, for instance to where an office is located, by turning the screen in the appropriate angle.

These four user scenarios formed the basis for the design brief of the entire telepresence system. For the functionality of the system this meant that the platform should be able to send and process data alongside the video and audio signal. In addition to this, the aim was to make the system flexible in the sense that it is possible to add functionalities in the future like scanning mail, have the visitors sign in, use an intelligent camera that focusses on newly arrived visitors etc. etc.. This implied that a modular system was preferred over a more closed structure like an off-the-shelf telepresence robot.

#### 6.4 Technology: off-the-shelf components and platforms

With the design brief described above, and a limited time frame, I needed to choose the materials and software systems that would be appropriate for the system. In collaboration with Artivisuals<sup>174</sup>, a company that specializes in camera control in Amsterdam, the Netherlands, I decided not to design and build a complete bespoke telepresence system, but to use off-the-shelf parts for most of the elements of the system. This had several advantages:

- The budget: building an elaborate system like the telepresence receptionist is complicated and requires, in general, more time (and a bigger team) to build, test and refine the separate functionalities when part of a bespoke hard- and software configuration.
- The software protocols were (partly) standardized as I used an industry standard camera pan / tilt head. In other words: we did not have to write all the code ourselves. Nevertheless, the programming proved to be more of a challenge than we anticipated.
- The system would be more flexible, easier to adapt to the input of the users group and also easier to reproduce.

Subsequently, a choice had to be made what software platform to use for the system. There is a wide variety of videoconferencing platforms but only few of them are 'open source'<sup>175</sup>, not owned by a software company but developed and organized by an open community of developers and programmers, that allow extensive data exchange. In a dialogue with Artivisuals, we chose Web RTC, an open source platform that is now owned by Google, but maintains an open source policy. This required a thorough risk assessment, in this case a SWOT analysis. The choice of a software platform is fundamental: in case it fails, it is hard to switch to another platform, halfway the design process. The SWOT analysis of using Web RTC in short:

**Strengths:** open standard, small but active community, providing us with the functionalities in our design brief without a (paid) subscription.

**Weaknesses:** not guaranteed by a large company (although owned by Google). In the beginning of the design process, there were no scripts available (the system is based on Java Script) for all the functionalities that had to be implemented.

**Opportunities:** the community was growing, the platform permits use of our own dedicated server on a local network so the system would not depend on

the stability of a server over the internet. Less privacy. High video quality and stable system.

**Threats:** the system is owned by Google and there is nothing preventing Google in the future from abandoning the open source principle of Web RTC. This could result in a subscription model, where the user has to pay a fee.

Summarizing: the Web RTC platform offered the technology needed for the videoconferencing and parallel sending of data for additional functionality whilst there was some risk of the platform being abandoned or commercialized by its owners or developers.

## 6.5 Third Iteration and evaluation

I designed the third controller, based on the evaluation of the first two iterations of the controller and the design brief of the telepresence receptionist,



***Figure 33: 3D sketch of third iteration and functional prototype, comprising a 3D printed sphere with zoom function.***

based on interviews with the prospective users and our observations at the workplace. I 3D printed a number of potential designs of the third iteration. In the first phase I printed two versions of the design, one with a sphere of 50 mm, one with a sphere of 45 mm. Feedback of the first two iterations suggested that users preferred a substantially smaller sphere they could manipulate with the tips of their fingers over a sphere that was in contact with the palm of the hand. My design (see Fig. 33) now had a cradle that supported the sphere better than the 'stem' of the first iterations.

I asked four test persons with small and large hands to manipulate it and comment. The diameter for the sphere that was estimated as the most workable was 45 mm. This time I included the electronics making it a

functional prototype. The ball that controlled the pan and tilt function. A wheel on the ball with indentation controls the zoom function.

After evaluating the 3<sup>rd</sup> prototype there were signals that the camera zoom as well as the tilt function, the moving up and down of the camera, needlessly complicated the system for users at both ends. During one testing session, where the tilting function had stopped working because of technical issues, users were observed to be better at aiming the camera.

For the next iteration, the interaction of the receptionist with the camera showing the visitor was limited to only the ability to turn the screen from the left to the right and vice versa. In this specific situation, where a receptionist has relatively little time to manipulate the screen, a tilt and a zoom function is subsidiary. In evaluations but also in our own experience when showcasing the first versions of the controller with tilt function, the zooming and tilting needlessly complicated the control. Regarding the experience of the system, the fact that the screen turns towards the visitor symbolizes the personal approach. In this respect, a tilt and zoom function does not deliver added value, neither for the visitor, nor for the person who controls the system.

Apart from the decision to limit the functionality of the new user interface, we wanted to also pay attention to the material of the final version of the controller. Rather than using 3D-printed bio plastics, the controller in the last versions is made of wood. Several wood qualities were tested. Finally a half sphere of oak was used for the last iterations. The half sphere has two basic functionalities: it can be turned to pan the screen and when pressed the bell at the other end rings (see Fig. 34).



***Figure 34: First prototype of the final controller, a wooden half-sphere.***

The dimensions are those of the third iteration, 45 mm in diameter, to accommodate for smaller hands. The interaction is still absolute: the wooden

sphere shows the direction the telepresence screen is pointed at the other end, it does not flip back to a 'neutral' position. This concept: a controller with a pleasant, simple, intuitive interaction, allows the receptionist to focus on his or her primary task, rather than putting extra effort in manipulating the telepresence screen.

## 6.6 User study for the final prototype

Before constructing the final prototype, I conducted a user study of the controller with 10 test subjects aged 27 to 76, 6 females and 4 males before constructing the final prototype. I used an industry standard joystick for camera control as baseline, and tested it against our controller. I created similar conditions to the receptionist's end of the system. In our user scenario, the receptionist controls a telepresence screen with camera on the other end and gets feedback from that camera on his or her own screen, but does not get any feedback of the position of the screen at the other end than that of the interface itself. The setup for the study consisted of, on the one side of the table: a laptop, the wooden interface and a joystick. Behind a dividing plywood plate, blocking the view of the test person, on the same table: a remote-control camera, and three targets. The subjects could only see the laptop screen, with the camera and targets out of sight (see Fig. 35). The users were asked to use the joystick first and after this the half sphere, because of technical conditions. This fundamental flaw<sup>176</sup> renders a test from scientific viewpoint less useful, I therefore only used the comments of the users of this test as feedback for the last phase of the design process.



**Figure 35: 3D sketch of the user study setup.**

The targets consisted of two wooden dolls and a ball shaped LED light in the middle. I asked the test persons to pan the camera behind the screen, with visual feedback from the camera on the laptop screen, from the one to the other target, framing them exactly in the middle. No time limit was given. All test subjects were given the same 9 tasks, the same for each interface, which were read aloud in their mother tongue. The tasks varied from very basic: 'pan

from the middle to target 1', and became gradually more complicated, e.g. 'pan first to target 1, then to target 2, then to the middle, back to target 2, back to the middle, back to target 1'. After the test, the test subjects filled in a query with a 5-point Likert scale with questions about their experience and preferences.

#### **6.6.1 Qualitative feedback**

Test persons were asked to comment freely during and right after the test.

One test person commented:

"I like the material of the wooden ball, but it took me a while to master it. I'm familiar with the joystick though and it feels also good to use it."

Several persons commented on the material of the ball interface:

"The ball looks nifty. I guess that is the idea, no?"

"Feels good but in the beginning a bit weird, because you're not used to this kind of interaction."

"Hey, the ball does not flip back, I see, but that can be practical too."

"Ah, wood, that's a change: does it really work?"

There were positive comments on the joystick too:

"Reminds me of my gaming years. I thought they would be obsolete long ago."

"Wonderful to use a joystick, feels familiar and comfy."

And then there were test persons completely at a loss with both interfaces:

"I'm not good at this. I know it's not about my skills, but I still feel awkward."

Negative remarks about the joystick had to do with the amount of force that had to be applied to manipulate it:

"This costs more energy than the ball."

"This feels like it is going to strain your muscles in the long run."

#### **6.6.2 Evaluation user study**

The test group was not explicitly negative about either of the controllers, but they considered the joystick a little bit better (6 out of 10 liked the joystick better than the half sphere). Because of technical constraints, I asked all users to first use the wooden ball and then the joystick. This may have influenced the data. I therefore regard this test as indicative but not decisive for the design process.

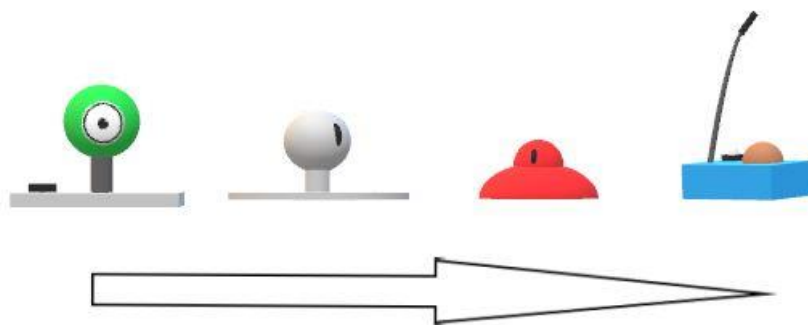
The most important takeaway was that users commented positively on the materiality of the wooden interface. Remarkable was also that users with experience with a joystick displayed a certain nostalgia for it. This was a factor I considered in the evaluation of the final prototype.

## 6.7 Conclusions for the final design

The controller used for the study is the result of a series of design and feedback sessions. During the design process, I gathered data that indicated a route for the design of the final iteration. In these sessions a number of decisions were made, based on input, our observations or for practical restrictions, like budget and time frame. The most important indications for the final design were:

- Simplicity in a functional design that only allows fundamental functionality is appropriate in this user context.
- We opted for off-the-shelf components, for the sake of feasibility but for a 'final' design, this might not have been optimal from a design perspective, but it allows evaluation of the interaction of the controller.
- The study shows absolute control, a controller that shows the status of the system, without flipping back to a neutral position, can be a viable option but users need to be 'guided' as they are not used to this kind of interaction.
- Materiality matters: appropriate material is appreciated by our user group.

In 4 cycles (see Fig. 36) where functions were combined and / or eventually stripped away we came to the design of the final controller (see Fig. 37).



**Figure 36: 3D sketches of the 4 iterations of the controller.**

The rudimentary control and functionality of the system provides the experience of being 'in control' of the system, rather than using a system with a number of functionalities where the user does not know of exactly, and / or does not know how to control all of them. The ambition of the control of the



**Figure 37: 4th iteration controller with LED button to open the audio / video connection.**

telepresence receptionist is that it allows the operator to leave the use of the system in the periphery of his or her attention when there is no visitor, moving the control of the system to the centre when the bell rings and a visitor announces herself or himself.

## **6.8 Building the working version of the telepresence receptionist**

The final prototype of the system was built based on the overall conclusions of the design process. The building process was also iterative: two versions were built, one version was used for in between testing of the system, the other the final design of the controller.

### **6.8.1 The reception end**

The reception end of the system addresses the visitor and sits on a tripod on the reception desk. A mini NUS Windows computer<sup>177</sup> is mounted to the back



**Figure 38: Telepresence screen at PROTO.**



of a HD 24" computer monitor that shows the 'real' receptionist in portrait mode. For the panning functionality, the monitor is mounted on a Second Shooter<sup>178</sup>, a remote control camera head for professional purposes. At the side of the screen, at eye height, a high-end camera and microphone is connected and at the bottom a high-end loudspeaker, that is rigid, so it does not pan with the screen (see Fig. 38). For the bell, I built a sensor into a generic hotel bell and an interface (between the sensor and the NUC), based on an Arduino (see Fig. 39).



**Figure 39: Hotel bell with USB connection.**

### **6.8.2 The receptionists' end**

For the other end, that is used by the 'real' receptionist who controls the system, I used a Microsoft Surface Pro 3 computer (see Fig. 40), connected to the bespoke interface, combining the control of panning the telepresence screen at the other end, ringing the bell at the other end, changing the



**Figure 40: Receptionists end, Surface Pro 3 with controller.**

messages on the telepresence screen at the other end and opening up the video / audio connection between both ends (see Fig. 41). In the final design, all functionalities were performed by the half sphere wooden controller, except the opening of the video / audio connection to the other end. From the input during the testing of the system in our studio and from input of users, it



**Figure 42: Controller at receptionists end: prototype and 3D drawing.**

became clear that such a functionality needs clear feedback, as the operator, the receptionist, has to be certain that he or she is either visible and audible at the other end or not. Therefore a LED button is built in the controller. The microphone for the operator (see Fig. 42) is built in the controller as well. The electronics of the interface are based on a similar Arduino as the hotel bell interface at the reception desk.

### **6.8.3 The final functionality of the system**

The system is designed to use the local area network (LAN) of an office. Because the telepresence receptionist can function independently of the internet, the possibilities to compromise its integrity from the outside are limited (see section 4.6.7). From the inside, it depends on the integrity of the network (and its operators). The design of the functionality is based upon the idea that the operator has an open video connection with the hallway or entrance space it is servicing. He or she can pan the screen and camera around to monitor the space. To attract the attention he or she can ring the bell and open up the video connection on the other end, so he or she is visible on the telepresence screen. The bells on both ends work at all times. All the functionalities I designed for my field trial in a row:

- System boots up automatically when computers are started. This had to happen in sequence; when booted up in the wrong order it fails.
- Default state shows 'please ring bell' sign at visitors end, operator can see visitors end, visitor cannot see operator.
- Visitor can ring connected USB hotel bell to attract operators attention at the other end at all times.
- When otherwise occupied, the operator can call up 'please bear with us' sign by pressing wooden interface at his end, bell will also sound at visitors end to attract attention. When the operator presses the half sphere controller again, the audio / video connection opens, signs disappear.

- Operator can open up and close audio / video connection by pressing LED button. When the connection is 'open', the LED is lit.
- Operator can pan telepresence screen plus camera at visitors end to address him or her directly or give directions.
- Operator can shut down audio / video connection by pressing LED button again: welcome screen boots up at the other end.

## **6.9 Deployment**

Starting the implementation phase, I performed a stress test of one month where the system was continuously booted up over the LAN of the location where the system would be set up. The system was tested daily: using the controller, opening up the audio / video connection, checking the start protocol.

Because the system runs over the LAN, the system administrator needed to provide fixed IP addresses. The technical staff of PROTO was helpful in solving the network issues of the system.

The programming of the Web RTC platform functionalities of the system, in JavaScript, and the Arduinos, was supervised by the Artivisuals company in Amsterdam. The first mock-ups of the controller were built in Dublin, Amsterdam and Berlin respectively. I designed and 3D printed the mock ups and working prototypes of the interfaces at the Northern Design Centre in Gateshead. Assistance in later phases, during the deployment, was provided by FabLab Sunderland.

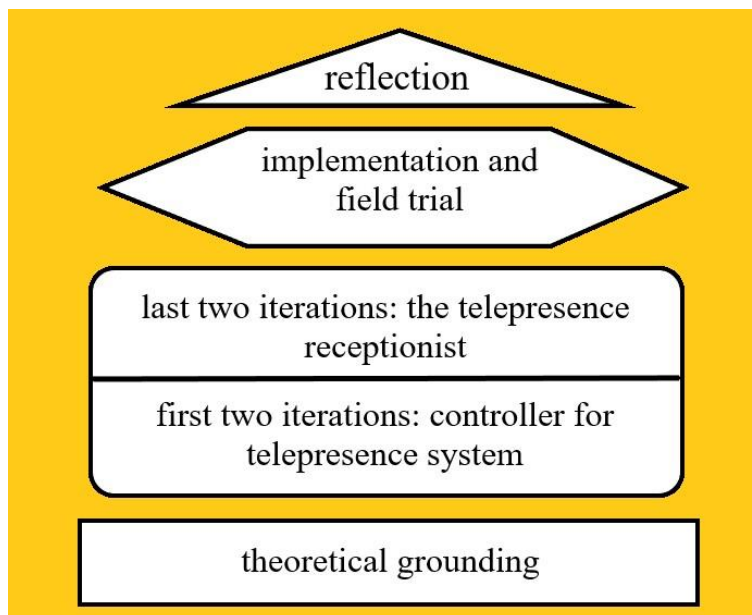
## **6.10 From stress test to reception desk**

After the stress test and the soft implementation, the system was deployed in the context it was designed for: the reception desk. Initially, there were some minor difficulties with the assigning of the IP addresses, but this took no more than a couple of hours. The team would alert me in case of technical glitches. I observed the use of the system for half a year. The results are described in chapter 7.

## 7. Field trial of the telepresence receptionist

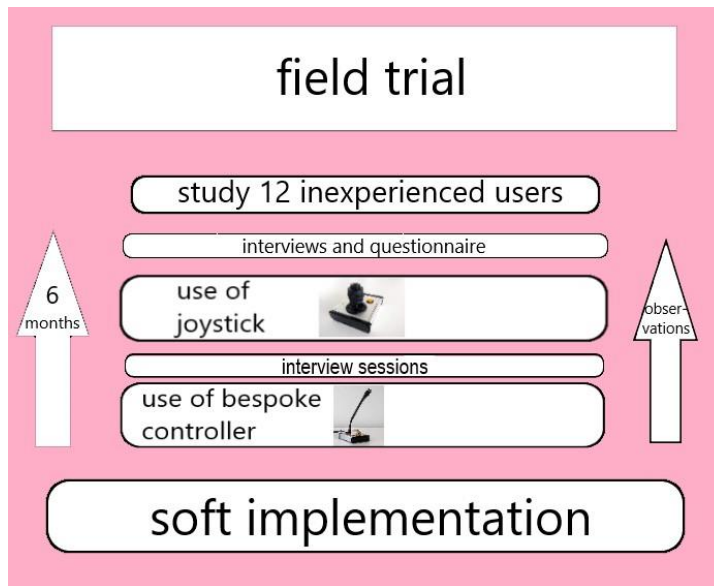
### Introduction

In this chapter I describe the results of the field trial of the telepresence system with the bespoke controller. After the intensive design process (see Fig 43), the system was introduced over a relatively long period of time to the user group.



**Figure 43: Overview process telepresence receptionist.**

Subsequently, the user group was invited to engage in workshops and asked for feedback. Then, the system was deployed in the setting it was designed for and regularly used. After two months, the users were asked to use a joystick as a controller for the same system. I was regularly present at the reception desks and observed the use of the system and its control. The users were interviewed and asked to fill in a questionnaire. After the six months, I asked 12 inexperienced users to perform a number of very simple tasks with the controller and the joystick and asked them to fill in the same questionnaire. The account of this field trial is in this chapter.



**Figure 44: Overview field trial.**

## 7.1 Evaluation process

The evaluation process of the field trial with the user group of 5 experienced users depended for a large part on the documentation of my observations and two sets of interviews, one halfway the trial, one at the end, and to a lesser extent on the outcome of a questionnaire. I consider the observations and interviews as the most meaningful result of this study. The questionnaires that were the result of the study with 12 inexperienced users at the end of the trial, give an indication of how novice users experience this form of control.

## 7.2 Data

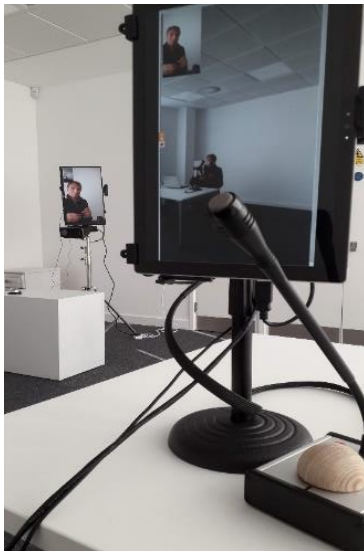
The use of the telepresence receptionist was documented by means of an ethnography (see section 4.1.2), two series of semi-structured interviews and a questionnaire. The user group also, after they used the bespoke controller for two months, was asked to use the most common alternative for this context, a joystick, to control the system for two months (see Fig. 44).

The interviews were held twice, the first session after the use of the bespoke controller, the second session after the use of the joystick. The questions in both interview sessions were the same. If something was unclear or when an interesting topic was broached, respondents were asked to elaborate. The interviews generally took half an hour to an hour, including the signing of the required permission forms.

After 6 months, I asked the users to fill in a questionnaire about the overall experience of the system. I was present at both reception desks regularly, observing the users and stimulating them to comment on the use of the interfaces, and documented that by making notes. At the end of the 6 months period, I also asked 12 inexperienced, novice users in the age group between 29 and 75 to perform 6 simple tasks with both interfaces, alternately, and asked them to fill in an identical questionnaire as the group of experienced users. I also conducted informal conversations about the use of the system. I documented the conversations and my observations during the 6 months.

### **7.3 Field trial: technical data**

Although the telepresence receptionist proved to perform reasonably well, there were moments when the system failed. After the stress test (see Fig. 45) using the PROTO network, the system was implemented in its designated location. In the 6 months that the system functioned at PROTO in Gateshead, some technical glitches were observed. Because of a change of provider, after 5 weeks of use, the IP addresses of the system were changed. It took a day to find out this was the reason of the system malfunctioning. Because of this, the system could not be used for 2 days.



**Figure 45: Setup stress test telepresence receptionist.**

After 7 weeks, a plug was taken out of the screen at the controlling end by a cleaner. It took about 2 hours to identify and solve the problem. Whenever there were questions about the system, I was generally available to answer them, mostly in person, sometimes via email. My presence at PROTO, where I also had my workspace, allowed me to frequently observe the use of the system.



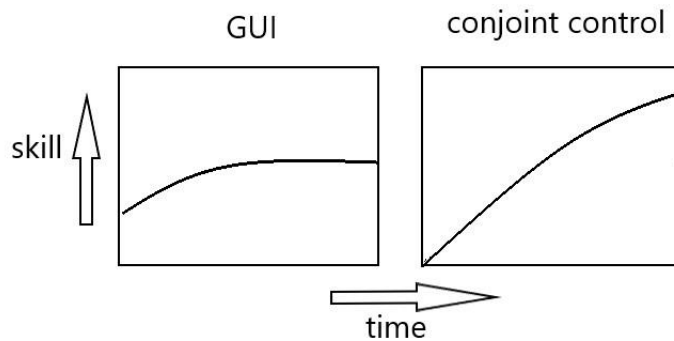
**Figure 46: Telepresence receptionist at visitors end during field trial.**

For privacy reasons PROTO did not allow me to interview the visitors using telepresence receptionist. I had informal conversations with visitors, but these were left out of the documentation process. Nevertheless, further studies of the experience of the visitors (see Fig. 46), who are likely to have an independent set of usability criteria, can be of value for further development of the system<sup>179</sup>.

#### **7.4 Soft implementation: skills and stress test**

Users are generally accustomed to the GUI platform model<sup>180</sup> where the skills and knowledge of a single interaction system are enough to master the interaction of an application. In this sense, alternative models have a disadvantage compared to GUI based interaction models: for every application a new set of skills has to be acquired. In the design process I observed my controller had a steep learning curve (see Fig. 51) that starts from the bottom: there is little or no prior knowledge of the interaction. On the other hand, the

controller allowed the user to master the interaction to a high degree. The bespoke controller facilitated a precise, intuitive control of the system.



**Figure 47: GUI versus conjoint control learning curve.**

GUI have a gradual learning curve that starts quite high on the skill axis: the user already has knowledge of the interaction model, but the control is less precise. To address this, I allowed the users a relatively long period to get accustomed to the system of the telepresence receptionist and the controller. Before the system was implemented at its designated location, I installed it in an empty office. I organized workshops where the users were introduced to the system and where they were asked to play with the system. This meant that users were reasonably proficient in the use of the controller and the functionality of the system when it was deployed, after about 6 weeks. This period also functioned as a stress test for the system itself as it was left running for the entire period to test its stability.

#### **7.4.1 Feedback during soft implementation**

Another motivation for the soft implementation was the collaborative design process of the telepresence receptionist that I extended into the implementation period. The system is built to allow tailorability<sup>145, 144</sup>: from off-the-shelf components that are easy to replace and reprogram. This allows last minute adjustments to the system.

The users were regularly invited to come in, use the system and give feedback. In the first couple of weeks the feedback was mostly related to the technical functioning of the system. The general feedback was that the control of the telepresence screen functioned too abruptly. This was addressed: the control was adjusted, made more gentle. Later the users commented about



the physical appearance and the graphics displayed on the telepresence screen. This was also addressed before the system was deployed.

This implementation period also ‘softly’ introduced me as part of the community at PROTO. Initially I had some reservations about this. I did not want to become too close with the users in order for them to be open and frank in their feedback. I discussed this with the team. I asked them to be frank and they assured me they wanted to be as open in their comments as possible, also in their own interest:

“In half a year you’ll be gone and we do not want to be left with a useless piece of equipment”.

We agreed upon a professional relationship although, like in any team, there were closer and less close relationships.

Users reported this procedure helped them with the acceptance of the system. It is different when ‘the management’ introduces a new technology than when the designer of a system personally takes the trouble to explain it and adapts it according to your feedback. I observed little of what I describe as ‘interface frustration’, an ‘I give up’ attitude when users did not understand the interface. No user commented that the functionality of the system was unclear to her / him.



**Figure 48: Implementation process, instructions for prospective users.**

During the deployment process I found that my role gradually shifted: from explaining the functionality of the system as such, to a person to whom the users could report feedback and as such participate in the design process. I regularly stimulated the users to ‘play’ with the controls, to explore the functionality, also when it was not a part of their daily tasks, like chatting or

showing objects to a person at the other end. Users commented that this approach, where they can explore a system freely, without focussing on the functionality, was uncommon for them. The instruction to 'play with the system', was experienced as positive. The appropriation of the system (see section 7.12) arguably correlates to this experience. The freedom to play with the system meant that users considered the system as theirs, especially designed and made for them.

The soft implementation phase delivered a number of insights:

- Users of this control model, even when the affordances indicate clearly their proper use, have initial inhibitions to touch and manipulate the controller.
- A longer, playful introduction phase can stimulate users to control the application.
- When users have mastered the interaction in a soft implementation phase, their use is more intuitive.
- A longer, more bespoke deployment phase makes users appreciate the appliance. A soft implementation can also make for more 'ownership', a more personal relationship with the application.

## **7.5 First phase**

In the first phase, when the system was just installed, I mainly observed and made notes, applying ethnography as a method. After 2 months, I conducted semi-structured interviews with the users for the first time. A consistent outcome of our study was that eventually all users, to a greater or lesser extent, enjoyed operating the telepresence receptionist. In interviews no respondent reported major difficulties in the interaction. Some of them thought it was 'fun' to use. This positive attitude did not happen overnight. I could detect some hesitation, especially with the staff, who were told by the management of the building to participate in this experiment. Because of these reservations among the user group when installing telepresence receptionist, I started out by asking whether or not the users had some hesitation before using the system. A responded:

"Reservations? did I? I can't remember that but maybe I was playing devil's advocate, to question it and find out whether or not it was right

for us. I have been impressed with it, I was not sure what it was going to look like, maybe that was my reservation, but I like how it looks, I like the bell, it gives it an authentic, sort of hotel bell feel, you know. I like that it has a large screen so it is clear for people, customers, that is it is there, there is a face there, you can't miss it. A positive first impression, I suppose."

There were remarks about the design of the telepresence screen, with the electronics uncovered at the back (see Fig. 47). D also commented on the design of exterior of the system:

"It could be designed a bit friendlier".

SN: "How?"

D: "The bell could be made more visible, or it could be more obvious what the bell would do - maybe a video on the screen."

On the topic of the experience of the controller, most comments were positive, although it needed some getting used to.

SN: "How is the interaction with the controller?"

A: "Fine, sometimes when you spin it quite a lot it does not stop, but I suppose you have to learn to work with it."

SN: "We can make it less sensitive."

A: "No I think it's getting used to it I suppose it's just fine the way it is."

User C on the controller:

C: "Yes it's just very straightforward, very easy to use, okay."



**Figure 49: The back side of the screen with server mounted to it.**

User E:

E: "It's just fine."

Concerning inhibitions about talking to the other end<sup>181</sup>. A responds:

"Talking to the other side? I have no inhibitions, but I notice some customers do."

SN: "What can we do about that?"

A: "I actually don't know if anything you can do makes a difference. You could put a sign at this end, but I would not know if that would make any difference."

Asked about using the system for banter, user E, who uses the system frequently says:

"No, usually not, because you can't know who's listening in to the conversation."

Receptionist C on the same topic:

"I definitely have conversations with D through it. But not often, like, we only turn it on if we actually need to use it."

I observed that after a 2 months of use, the operators became more proficient in the use of the controller. The function can be operated by very slight finger manipulation. This was performed quite intuitively, especially by the most frequent users, participants A and E. Users also indicated they appreciated the wooden material of the interface. D comments:

"It looks and feels good."

User E says:

"It's not really hi-tech, but that's a positive."

Because I wanted the controller to be part of a functional, effective system to evaluate it as part of the daily routine of office workers, I asked the users questions about the system in general, especially whether or not the user scenarios are clear and serve their purpose. According to our user group, the user scenarios are rudimentary but serve most purposes of a receptionist. There were remarks about the booting up of the system, because this needs to be done in sequence: first the server part, the telepresence screen, and then the operator's end with the controller. Although the rest of the system starts automatically, no special software has to be booted up, this was seen as a barrier to use the system. For user D, as well as C this proved to be a nuisance sometimes. User C.:

C: “..would be nice if you would be able to start it with one button.”

D: “It would just be more practical if it could be started in say 30 seconds than 3 minutes.”

User E suggests, concerning functionality, that there is already a computer and other equipment on her desk and that she would like all these to be integrated with the telepresence receptionist:

“There’s so many wires on my desk, I sometimes get confused. It would be good if all the electronics were integrated into one big system.”

B and E suggest an extra sign next to the telepresence screen stimulating visitors to really use the bell is needed. Although there is a clear sign on the telepresence screen, users ignore this message.

The takeaways of the first set of interviews were:

- The controller feels good, no problems reported operating it.
- The controller is appreciated as a novel, interesting feature of the telepresence receptionist.
- Users have no problem using the system; they don’t mind talking to visitors via the audio / video connection and use the controller frequently to pan the screen towards the visitor.
- The design of the telepresence screen is experienced as rudimentary.
- Operators experience the telepresence screen as a ‘window’ to the other location: the idea that they can monitor the other end provides a feeling of control.
- Operators have the impression that visitors have inhibitions when talking to the telepresence screen.
- User scenarios work more or less as expected: system as such is understood and used frequently by users, about 5 or 6 times a week.
- The booting up of the system should be simpler.
- Extra communication to stimulate visitors to use the system could be helpful.

Observations during this period:

- The user group engages in informal communication with each other over the system, chatting, mainly when the office is closing down and there are hardly any visitors.

- Visitors sometimes ignore the system, once they have rung the connected bell, and have fewer inhibitions to talk to the screen.
- The user group needed a while to get used to the system but took ownership of it after 4 or 5 weeks, using it more frequently.

### 7.5.1 Second phase: evaluation controller after four months

To compare the experience of the controller with a more generally used interface, I switched in the second phase, the bespoke controller for a joystick with a similar functionality (see Fig. 48) and asked to use it for two months. In the second interview session that was held after 4 months in the field trial, I discussed the difference between the bespoke controller and the joystick with the users.



**Figure 50: Joystick based controller.**

The controller was appreciated, but not preferred by all users.

User B. (assistant manager) enjoyed using the joystick:

“I think it added something to it. I think it was just like a childhood thing and playing up in a game, some things that output I don't know it, did it was slightly more enjoyable to use then the sort of original sort of the device I think and I personally enjoyed it and find it easy to use as well.”

A liked the controller:

A: “I like the design of the ball. It's nice and simple to use. The first time I used it I thought it had a bit of a joystick functionality but now I know how it works, it's fine. It's nice and easy.”

User E (most frequent user, no experience with joysticks) definitely likes the bespoke controller better, asked about the joystick she responds:

E: “its troubles.”

SN: “What do you mean?”

E: “I think it's (the ball shaped interface) just quick, you want the system to be quickly you know.”

Some respondents mentioned the joystick caused more strain on the wrist muscles. User E:

“You do need more force to get it [the joystick] moving, and when you're busy doing other stuff that can be more difficult.”

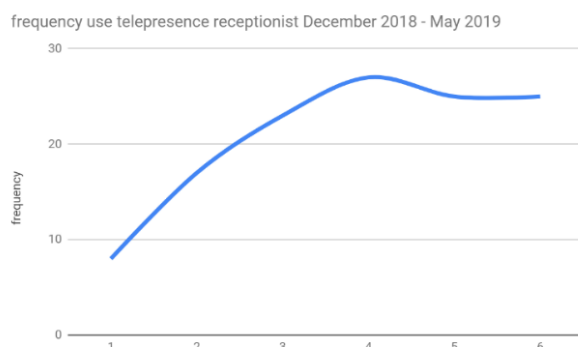
There was no real difference observed between the use of the controller and the joystick. The user group used both controllers with as much enthusiasm but some users had their favourite way of control. Two users found it a nuisance to have to become familiar with yet another form of control. The users with no prior joystick experience tended to like the interaction model that they were used to. The users with joystick experience obviously had no problems with it.

The experience as reported in the second series of interviews can be summarized as:

- Of the 2 interfaces, the controller was more popular with the frequent users.
- Users with a (joystick related) gaming background liked the joystick better.
- The bespoke controller was seen as designed especially for these users and appreciated because of that.

### 7.5.2 Frequency of use

I observed that the team started using the system more, quite gradually, from 3 or 4 times a week to even a couple of times a day (see Fig. 49) . The reason why the system was gradually used more frequently over the 6 months period, as reported by the staff, was that after about two months, the team



**Figure 51: Frequency of use telepresence receptionist.**

implemented the use of the system in the organisation of their workload. In other words: they counted on the telepresence receptionist to cover for a 'real' receptionist. Its use was not an added functionality any more, but a more basic feature in their set of tools. When colleague C announced her leave, for instance, the use of the telepresence receptionist would be implemented in the schedule: "at that time B will cover both ends with the telepresence receptionist". The users also mentioned they felt more in control of the system now. User A:

"It is quite easy: the new interface once we've got it on and everything, it is just very simple, which is no problem because that is what you want from technology isn't it? I personally struggle sometimes with technology. I actually think, from a user point of view, some technologies are getting harder to use. I think you need to know quite a lot to even go on an iPhone. Like for us to give it to my mom she'd be like: 'what is syncing?' and things like that. I think it's getting quite difficult. We've got an example of a presentation system in the hall at PROTO and D and myself and another colleague could not get it working and we just I think from a user point of view you want to be able to just use technology in 2019 and it should be very very simple. This is system works when switched on and it's simple so that's good for me."

The system also functioned as a marketing instrument of PROTO. This can also have been a reason for the growing frequency of use. User C:

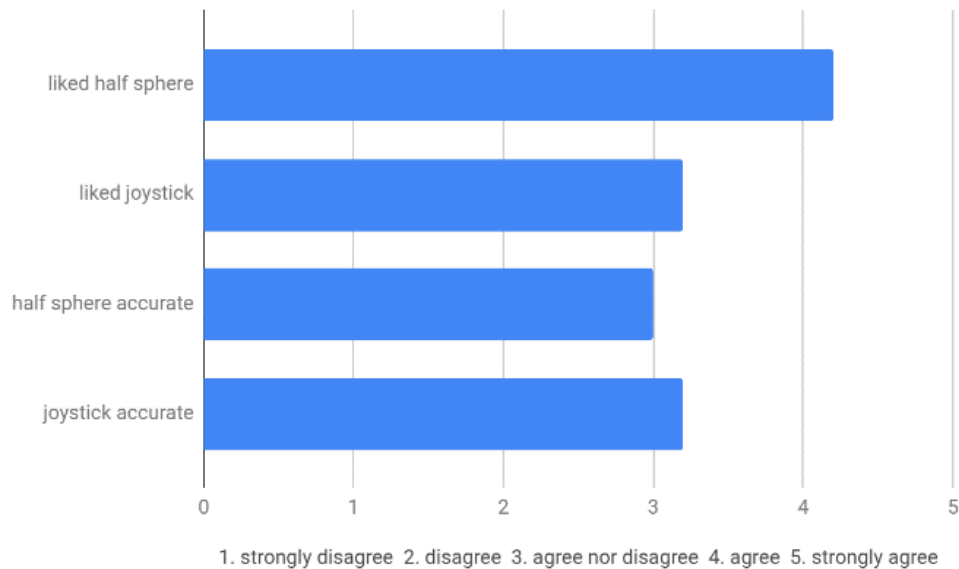
"But when people come, in particular quite important clients, we do sort of show people around and the telepresence system is one of the things we tend to show."

I observed a number of times that the telepresence receptionist was showcased as one of the features of PROTO. One of the users commented that the telepresence receptionist was an appropriate introduction instrument. Its design, constructed from off-the-shelf parts, with cables sticking out of the back, made it look like a real 'prototype'. I observed a couple of times that the user group intentionally welcomed new visitors with the telepresence receptionist to illustrate what PROTO is about.



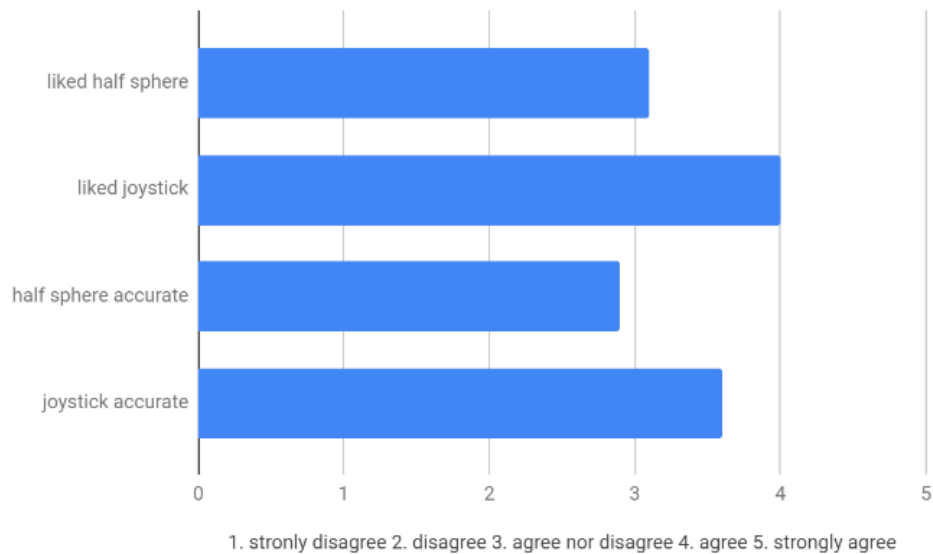
## 7.6 Questionnaires

At the end of the 6 months test period I asked the team of regular users to fill in a Likert scale based questionnaire about their experience with the TUI and the joystick. In this questionnaire, more users indicated they appreciated the conjoint control, rather than the joystick. In particular, 3 users 'strongly agree' with the statement: 'I liked using the wooden half sphere controller for the panning screen', while 2 users filled in 'agree nor disagree'. On the statement 'I liked using the joystick controller for the panning screen', one user filled in 'strongly agree', one user filled in 'agree', while 2 users ticked the 'agree nor disagree' box and one user the 'disagree' box. Nevertheless, more users agree with the statement: 'The joystick controller is more accurate', than with the statement 'The half sphere shaped interface is more accurate'. (See Fig. 49 for averages).



**Figure 52: Averages experienced users controller versus joystick.**

At the end of the field trial, I also conducted a qualitative study with 12 users to explore the experience of users that had not used the interfaces before and also did not experience the soft implementation. I asked 12 users in the age groups from 30 to 75 years old, 4 female, 8 male, to use the controller and the joystick, in the in situ set-up. During 2 consecutive weekends, when the reception desks were not manned, I asked them to perform 6 simple tasks with each interface alternately, 6 using the controller first, 6 using the joystick first. After the tasks I conducted a brief interview over the system and requested the test persons to fill in the same questionnaire I asked our 5 person, experienced user group to fill in.



**Figure 53: Averages novice users controller versus joystick**

The results differed considerably (see Fig. 50): a majority of test persons did not agree with the statement ‘I liked using the wooden half sphere controller for the panning screen’ and a majority of users also thought the joystick was more accurate. One test person, a male non joystick user of 75, said:

“The ball interface feels nice but I have to get used to it. It overshoots easily and that is hard to correct. I can imagine it works fine once you’re used to its sensitivity”.

Another test person, female, infrequent joystick user, commented:

“The joystick is just a generic thing: you know what it does and how to use it.”

## 7.7 Peripheral awareness

Asked about peripheral awareness, the fact that the system always shows the other end from the operators point of view (contrary to the visitors end, that can be opened by the controller), being a distraction, respondent A:

“I suppose it can be a distraction when it's on. Because you're constantly aware of what is going on at the other end. But for me it's different, because I'm not a receptionist, I just cover when we're understaffed, so I have lots of other work. Anything at the reception is a distraction from my other work. I just get on with it (my other work -SN) on any computer. So that's not relevant, I think it's probably a good thing that it's a distraction, I'm responsible for the running of both

receptions so I like it that receptionists are aware of what's going on here. I like the fact that I can spin it around and make sure I haven't missed anyone or just check if anyone is not doing things that they shouldn't in reception. And I want the receptionists to use it."

User E, who frequently uses the system, responds it can be a distraction sometimes to always have an open connection:

"It's a little bit tricky sometimes when, that's going and it's just a time management of who do I see to first."

No respondent experienced the peripheral awareness of the system as negative. Most users referred to this experience as a 'window to the other side': you can look out of it but mostly you don't. When there's something going on at the other end, you look, when all is quiet, the window moves to the periphery.

## **7.8 Embodiment in the field trial**

As mentioned in chapter 2, there are many ways to interpret the design of embodiment. For my purposes, looking at the interpretation of the term that I adopted from Dourish<sup>84</sup> who, discussing why embodiment is relevant for HCI argues it 'denotes a form of participative status'. Embodiment is in his view about the fact that things, objects, are 'embedded in the world and the ways reality depends on being embedded'. The embodied quality of the telepresence receptionist is that it acknowledges the environment where the system is deployed and the social and organizational factors that play a role in the interaction design of the system. The more inherent embodied quality of the controller is that it is obviously an object that controls another object with a tight coupling between input and output, between the manipulation of the controller and the result of it.

I observed that users appreciated that the telepresence receptionist was part of their environment, that it was designed for their specific situation. Also during the implementation process, users experienced the controller as a natural part of the reception area, where visitors are being welcomed. The input of users, where they commented on the design of the system, indicated they interpreted the telepresence receptionist as theirs, and even personalized by giving it a nickname.

The direct form of control, where the controller indicates the position of the telepresence screen, was appreciated by novice users of controllers. Users with experience with joysticks preferred the joystick. The concept of 'looking around' with the controller was mentioned by two users. Users also report that they like the feeling of 'being in control', the feeling they have mastered the interaction and are able to use the system effortlessly.

The results of study of the embodiment of the system:

- The embodied quality of the system in the sense that it was designed to be a part of their environment was appreciated by the long term users who had the time and the opportunity to familiarize themselves with the system.
- Long term users enjoy the system where they feel being 'in control' of the direct functionality.
- Long term users appreciate the experience of being able to 'look around' controlling the system with conjoint control.
- The appropriation of the system, giving it a nickname, decorating it for Christmas is an indication of users experiencing it as embodied.

## **7.9 Analogies with media spaces**

In section 3.4, I discuss the concept of media spaces in the framework of computer supported collaborative work (CSCW). Media spaces are described, by Buxton et al.<sup>144</sup>, Bly et al.<sup>141</sup> and Gaver et al.<sup>145</sup>. The set-up comprises spaces where there is an audio / video connection, supporting collaboration between people in those spaces over distances. One of the vital functionalities of media spaces draws on the peripheral senses: the video monitors are not always in the centre of attention of the users, but the awareness that there are people, colleagues, at the other end, is experienced as a positive incentive for the collaborative process.

In my field trial there are similarities with the experience of the media spaces. Some of the group of 5 users in the field trial experienced the telepresence receptionist 'as a window' to the other end. Users report that they do not actively watch the space at the other end but feel more secure knowing they have an 'open' audio / video connection where they are able to hear and see

what is going on at the other end, albeit from the corner of their eye. Some users also report that they sometimes actively pan around the telepresence screen to 'scan' the other space, not for a specific reason but "to see if somebody needs help". During down-time the video connection was also used for chatting or to draw each other's attention.

One of the observations is that the open video connection in this defined context can have a very distinct functionality. In the media spaces set-up, the functionality of the ambient awareness is sometimes ambiguous, in the telepresence receptionist, the functionality of the ambient awareness is more defined and functional. Users, in the case of the telepresence receptionist, feel in control because when needed, they can turn the screen and scan the other space. They can follow up on it by drawing the attention of people at the other end by ringing the bell and talking face-to-face to them. Users report that in the first weeks when they used the system, they looked at the screen more than necessary. It took, according to their comments, 'a couple of weeks' to get used to this more implicit function.

#### **7.10 Reflection: pet project**

During the 6 months of observations, I documented a change of attitude of some people (not all) in the team towards the telepresence receptionist. It evolved from initial distrust, to being a pet project. PROTO is branded as a prototyping lab for start-ups. The fact that there is a prototype greeting the visitor at the reception desk was experienced as interesting. This implies that the responses of the team can also be seen from this perspective: from a slightly biased position. There were also participants who were less sensitive to this 'frame' and gave their opinions freely. There were even users who saw this frame of the telepresence receptionist as inappropriate because prototypes like this are not made at PROTO, it focusses on other technologies. Reflecting on this development, I come to two different notions:

- It can be seen as a compliment when the system designed is at one point in time seen as a pars pro toto for the context it is deployed in.
- A reception like this can influence the opinion the users, either for them to give negative or positive feedback.

### 7.11 Design qualities

In retrospect, my attention was drawn to the concept of a designed research product<sup>182</sup>: a perspective that takes prototyping to a real-world context. The authors, Odom et al.:

“..propose the research product as an extension and evolution of the research prototype to support generative inquiries in this emerging research area.”

In this scope, the authors articulate four different ‘interrelated qualities’ of research products:

- Inquiry driven: the research products ambition is to initiate a research inquiry by making and experiencing a design artefact.
- Finish: where the finished product is emphasized and not the product it can become.
- Fit: the aim is for the design artefact to be lived with, in a real-world situation for a longer period of time.
- Independent: a research artefact that can be operated without the researcher intervening.

This perspective relates to the field trial of the telepresence receptionist that incorporates at least some of these qualities. The quality that is from my perspective the least applicable to this study is ‘finish’, as the prototype that was used by no means had the ambition that it would be a finished product. The exterior, the design, communicated the telepresence receptionist exists to function as a study object but would not be a finished product. The telepresence receptionist to a greater or lesser extent possessed the other qualities: it was definitely there to initiate an inquiry, to articulate a research question, it fitted in the sense that it was designed to function over a longer period of time in a real-world situation. To some extent it was independent, meaning it could function, and functioned without the researcher present.

Taking notice of this perspective was a positive experience. It acknowledges partly the methodology I followed but provides it to a certain degree with ‘grounding’, albeit after the fact.

### **7.12 Acceptance of the system: longitudinal use**

The data generated by observing and talking to the users and test persons for six months shows that the longitudinal users of the controller reported a certain attachment to the telepresence receptionist and its control. The user community gave input for the design of the controller and the system and that might have been the reason for their positive attitude. But I noted more neutral or negative comments too. Later in the project the controller started to wear out and this was noticed by the community and sometimes complained about.

In general, the system was more and more approached, maybe for better or for worse, as a part of the working environment. An example of the affection of the users for the system was the appropriation of it by the users. For Christmas they decorated it (see Fig. 53). Users even gave the system a pet name: the 'RaeBot', named after the team member who is visible regularly on the telepresence screen.



***Figure 54: Christmas decorations of the operators end of the system.***

### **7.13 What the data told me**

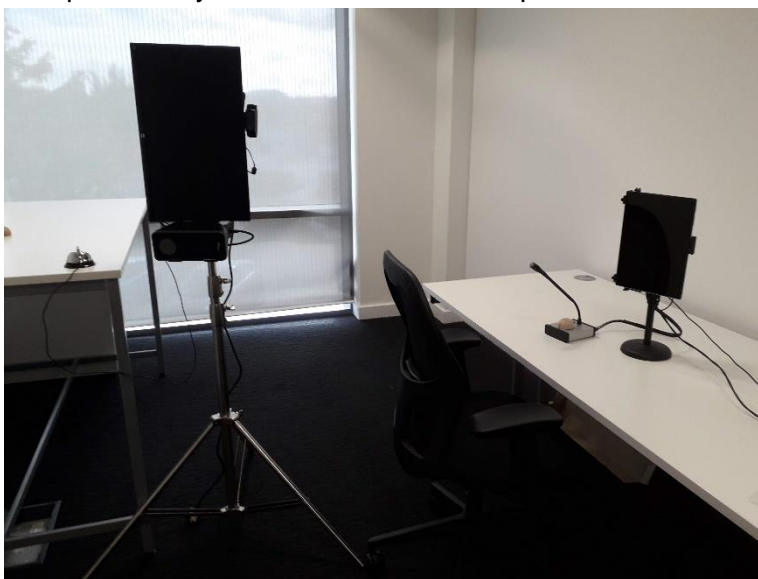
In short, the field trial of the telepresence receptionist and its control provided me with two important insights: the collaborative design and implementation process in this context is an option that provides a better design and user acceptance, and second: the approach I followed has a number of aspects that deserved to be followed up on. I will specify these findings in chapter 8.



## 8. Conjoint control and the telepresence receptionist: discussion and future work

### Introduction

I designed, built and deployed a telepresence system applying a user-centred approach. Subsequently I did a field trial of the system that features a simple form of control. I wanted study a working prototype in its proper, real-life context. My perspective is that of an HCI practitioner (see Fig. 54). The design process was collaborative: experts and user panels gave feedback in several iterations. The product of this cycle, the actual design of the system that was installed in the PROTO centre, allowed me to do a field trial with a core group of 5 experienced users. This user group was introduced to the system during a relatively long period of 5 weeks. In these weeks the users became accustomed to the user scenarios and the way the system is controlled. In this process, users were also asked for feedback about the design of the system and its appearance. This resulted not only in updates of the system, but also in an intimate relationship of the users with the telepresence receptionist. They accepted the system and took ownership of it.



**Figure 55: Building the telepresence receptionist.**

This methodology has its inherent limitations and I subscribe to the idea that the results of my exploration are context-dependant. But although the study focusses on the control of a telepresence system, the evaluation of the control can potentially have meaning in related contexts, like camera control or navigating in a virtual environment (VR).

Was it a flawless process? In retrospect, I found that, as in every design and research process I was engaged in, I overlooked issues and made mistakes. Nevertheless, the rigid design cycle and the scheduling, the feedback of user panels and the critical view of my supervisor were the structural approach that kept the process on track.

In this chapter I will reflect on the entire process, will summarize what the results are and its implications, as a discussion, as an addition to the HCI toolkit and for further research.

## **8.1 Reflecting on observations and conversations**

Observing the use of the controller and analyzing the conversations was not always without its issues. Sometimes it was a challenge to determine whether or not the user group reported on the controller or on the controller as part of the telepresence receptionist. The novelty effect, the idea that the employees of PROTO had a bespoke, new tool they could use, attracted attention. This attention worked two ways. The employees were more aware they had a new appliance that was uniquely designed and made for them and therefore put more time and effort in mastering the system. On the other hand, because of their ownership, they were more critical of the system. This was noticeable when the system failed or did not work properly: they felt that they were let down and that they were let down by the system and its maker.

This distracted sometimes from the evaluation of the interfaces, that was seen by some of the team as a detail, as a necessary part of the system but not its most important feature from their perspective: the panning screen at the other end with the 'real' hotel bell. Over the months, the 5 users became more open about their critique of the system.

Another observation was that users felt that using the telepresence receptionist, they had acquired a 'skill': without the telepresence receptionist they would have never operated a remote controlled screen and camera. Over the course of the field trial, receptionists became more aware of their looks and had the feeling they were 'on display'. They adjusted their clothes or make-up before they opened the connection. One of them did not experience this as positive.

Some users reported that they felt 'in control', that they had control of the telepresence receptionist, albeit that some users still had reservations and felt that there were functionalities they had overlooked or forgotten. Receptionist E for instance was noticeably startled when she pressed the controller and rung the bell at the other end while panning the remote screen. Although she was observed using the bell in the first weeks, she had gradually become unaware of this function.

Reflecting on the entire process of the field trial, the most important notion is that the relationship with the community of users was in general good. Our conversations were pleasant and the users were aware of the role they played. The users allowed me to observe their use, during all moments of the day, also at moments when things were running not so smoothly. I realize that this could have been different and I am grateful for the generosity of the user group.

## **8.2 The research question**

My research question was: 'Does the embodied tangible interface, for this well-defined and relatively simple task, provide an intuitive, positive experience for long term, experienced users?' I broke this question down into four separate sub-questions:

- How does the collaborative design process and the long implementation phase influence the experience of the system?
- What is the added value of the one-on-one interaction, the absolute control, to the experience of the system?
- How do users appreciate the limited array of tasks of the system?

- In what way is the approach I took: the user-centred, collaborative process to design an simple system where users could provide feedback until the implementation phase, an appropriate model for further explorations?

### **8.2.1 Collaboration and implementation**

Especially in the implementation phase where users could give input on the direct functionality like the sensitivity of the controller, and the appearance of the system, has several, also unexpected implications. Firstly, the user group was familiar with the system when it was actually deployed. This was an advantage. The users were more relaxed using the system and used it with confidence.

Another result of the extended implementation period was that users provided feedback that improved the experience of the system. Firstly they provided input about the way the telepresence screen at the visitors end was positioned. I acquired a new tripod to position it on the reception desk, rather than behind the desk and this was appreciated by the users, but also by me: the screen was a lot closer to the visitor and provided a more realistic image of the 'real' receptionist. Also the message for the visitors on display on the screen advising them to 'ring the bell' was redesigned, by the users themselves, in this case. The last adaptation that was made was the tweaking of the speed of the control.

This list of feedback and the way I responded to it made the user group experienced the system as theirs, as made for them, which was completely true. It also led them to react more positively to the use of the system: they liked it, for better or for worse. Overall, the complete process where the system's last iteration was done in collaboration with the user group of the field trial had a positive effect on the acceptance of the system.

### **8.2.2 Tight coupling: absolute control**

The engineering of the control of digital systems<sup>183</sup> is a science of its own and during the building of the control of the telepresence receptionist I was aided by a professional in this field of expertise. Most digital controllers inherently are not absolute: we are used to the control switching back to a neutral position, like for instance the joystick. From an engineering viewpoint this is relatively easy to put together: most hardware and software systems are

geared towards this interaction model. Building a simple absolute controller was therefore a substantial challenge. We managed to build a controller that once calibrated, indicated the position of the remote telepresence screen, although it needed recalibrating twice over the period of six months.

From the perspective of the user, the way they approached digital control, also had to be 'calibrated'. The one-on-one relationship of the controller with the output, in particular the turning (panning) of the telepresence screen was one of the fundamental features of the controller. In the soft implementation phase, where the user group was introduced to this form of control, users commented they found the control too abrupt. We programmed it to respond slower and this was appreciated by the users.

How the tight coupling between the input and the output was appreciated in the long run was harder to assess. The team of 5 persons that used the system for 6 months describe the experience as better than the joystick, which is confirmed in the questionnaires, but in the questionnaire also indicate it is slightly less accurate than the other interaction model, the joystick (see section 7.6). The 12 novice users experienced the joystick as better and more accurate than the bespoke controller.

Regular users of joysticks in gaming contexts, although appreciating the control of the dial and its absolute capabilities, commented they found it less accurate. They were used to the interaction model of the joystick that when they 'overshot'<sup>184</sup>, moved the screen too far, they automatically corrected by moving the joystick back. Novice users of the controller, at the end of the period, got reasonably proficient at it, aiming the screen quite fast without overshooting.

There is a restriction to these observations: only one form of direct control was built and observed. Obviously, we are at the beginning of testing these forms of direct control and there are many other ways to design and study these forms of control. What this study shows is that the approach of conjoint control has the potential to be appreciated and applied effectively. There is an abundance of possibilities for the approach of this form of, more embodied, control. This study indicates it is a worthwhile direction to explore.

### **8.2.3 Simplicity**

Another fundamental concept this study builds on is the simplicity of the system, the idea that an application that performs a limited amount of functionalities outstandingly, can be a viable alternative for the platform model where one system performs a large number of functions in a sub-optimal way. This is of course restricted to a number of contexts and not a model for all forms of interaction.

In this respect, the results of this study are quite convincing: all users indicated they appreciated the simplicity of the system and the straightforward functionality. Users report they value the limited amount of functions and the fact that they are able to control all the features. I argue that this approach: to collaboratively design simple solutions for mundane applications, is an interesting angle for future research.

### **8.2.4 An appropriate model**

The discussion whether or not the approach of this project is appropriate for these specific contexts, is at the core of this thesis. The design process of the telepresence receptionist and the field trial, including the soft implementation phase, shows that users in general have a positive attitude towards this user-centred perspective. Over the course of the six months this field trial took, the attitude of the users became more positive, but also more engaged: they wanted the telepresence receptionist to function. Remarkable was also that the users kept providing me with input about the colour but also the functionality of the system. These results are context-dependent: another context with another user set and researcher can generate different results. But I argue that the engagement of people in their workspaces with the applications they have to work with, is a generic phenomenon. People have a relationship with the tools they use. In this study this relationship was intense and according to the users worthwhile. This in itself is a value, as the users indicated also they rather work with tools they appreciate than with generic, anonymous appliances.

### **8.2.5 Conjoint control and the field trial**

The process that lead to the field trial of the telepresence receptionist delivered an approach that I call conjoint control. My objective was to design in

a user-centred, collaborative process and evaluate whether or not this is a worthwhile approach to design such tailored systems.

I did a thorough study of the environment the system would be deployed in, of its embodied quality and I engaged in a collaborative process with experts, some of them also active in maker culture. Then there was the decision to make the system from off-the-shelf parts, that made for more flexibility in the user-centred approach. There were furthermore last minute adaptations according to the input during the soft implementation phase. I took time to implement the system, although there was a strict time-schedule.

These factors influenced this study positively: they resulted in a functional, durable and tailorable system, implemented in a community of end users where I could perform the field trial. These last three qualities: functionality, durability and tailorability are in retrospect the most successful elements of this project. They lead to the high acceptance rate and the opportunity to study this system in its 'natural' context. This indicates that, at least in this context, the approach of conjoint control delivered a viable results that deserve to be followed up on.

### **8.3 Recapitulating: conjoint control and the telepresence receptionist**

The approach of what I call conjoint control is something that crystallized over the course of this study. The collaborative, user-centred, design process of the telepresence receptionist, was one of the starting points, as was the idea to build a simple interaction model. Halfway the design process, I decided to use off-the-shelf parts to build the prototype, because of cost efficiency and practical advantages. During the process, the idea arose that new, bespoke ways of control like of the telepresence receptionist might best be introduced over a longer period of time, allowing the users enough time to learn how to work with it. When executing the implementation process, I asked for input from the users and noticed that the fact that the system was built from off-the-shelf parts was actually a benefit, rather than a drawback. It allowed easier last minute updates, the easy replacement of parts and easier programming of software.

At that moment in time, I also realized that the project did not fit very well under the umbrella of the TUI paradigm. The approach I took was too specific and the result of the design process had only few elements of 'a' TUI. Reviewing and evaluating the process after the field trial, I concluded that my approach had its specific qualities but did not fit into a single design approach. Therefore I decided to give the approach a name: conjoint control. 'Conjoint' has its meaning as combining, as well for people as for things and 'control' defines a more down-to-earth perspective on interfacing: the direct manipulation of objects.

In summary, conjoint control is a design approach with:

- a strong user-centred, collaborative, perspective with input from experts and users
- an inherent role for constraints and affordances in the design of simple interaction
- a limited array of functionalities
- embodiment, in the sense that it is implemented as part of its environment, the people and the systems its functioning in
- a modular design, from off-the-shelf components, bespoke, drawing on the knowledge of maker communities
- an extended implementation period

This approach appropriates the new prototyping technologies of the last 15 years and welcomes the maker communities that are facilitating empowerment of groups of people that can benefit from this approach. The relationship between HCI and maker culture<sup>185</sup> is of relatively recent date but has the potential of providing large groups of people with the means to design their bespoke, personal applications. The combination of the methodologies of HCI with the streetwise knowledge of maker culture can be an opportunity for both communities to contribute to a change to a more small scale, smart, personal, independent design of computer systems.

### **8.3.1 Collaborative approach**

The telepresence receptionist could not have been made without the collaborative, intense design process. From the ideation to the design cycles and the implementation phase I involved professional and nonprofessional



users as well as experts. In this cyclic approach it was my task to put the pieces of the puzzle of user input and expertise together.

In the design process I linked local initiatives to the global communities of open software. This resulted in a dynamic process that allowed last minute adjustments to the design, keeping the door open for user input at all times, also in the implementation phase.

### **8.3.2 Constraints and affordances in the design process**

The design process of the control of the telepresence receptionist started from a very simple, space multiplexed interaction model. From there, it navigated between less and more direct control of the functionalities. Furthermore, the number of functionalities was scaled back until an effective, yet intuitively controlled, system remained.

This process, a constant trade-off between the functionality and the constraints and affordances of the system, resulted in a rudimentary interaction model consisting of two ways of control: a LED button and a half sphere shaped wooden controller. The wooden controller affords two ways of manipulation: turning and pressing it, resulting respectively in turning the telepresence screen and ringing the bell. The turning of the controller refers to the looking around at the other side, pressing it to ringing a hotel bell. The interaction is straightforward and experienced in the field trial as intuitive. The LED button had only one functionality: to open or close the audio / visual connection.

### **8.3.3 Limited array of functionalities**

At the end of every cycle of the design process of the telepresence receptionist one of the questions that was asked was: what functionality can be omitted without hampering the function of the system, creating a more intuitive control?

In the second iteration, the separate slider controlling the zoom function was implemented in the control ball. Feedback from users and experts indicated that either manipulating the zoom function in sequence or using two hands were not an elegant solution.

In the third iteration, the zoom function was implemented in the ball in the shape of a mouse wheel with direct, absolute control: the position of the mouse wheel indicating the position of the zoom of the camera. Users commented that the panning of the telepresence screen as well as the zooming confused them somewhat, rather than giving them an intuitive interaction. In the last iteration, both the tilting of the telepresence screen and the zoom function were left out. This resulted in a design where the telepresence screen only panned (turned) with no zoom.

In retrospect, this scaling back of superfluous functionalities was experienced as rewarding: the interaction it resulted in is straightforward without distracting features that do not add to the experience or functionality.

#### **8.3.4 Embodiment**

The aim to design and build an embodied system relying on the concept that the screen of the telepresence receptionist represented a 'real' receptionist in the context of a reception area. The connected hotel bell that signals that there is a visitor, is also part of this context. The controller allowed the operator, the real receptionist, to coordinate the communication.

The interaction of the telepresence screen, representing the real receptionist, was experienced as embodied, in the sense that the screen was used to look around, look the visitor in the eye and communicate. The controller facilitated this in an unobtrusive, intuitive way.

The particular qualities of embodiment as I have adopted them for this study, can be divided in two. On the one hand the more metaphorical interpretation of the role of the interaction in its environment, the physical world<sup>84</sup> with the people and social structures in it. On another more down-to-earth level, I interpreted embodiment as a direct form of control where there was a one-on-one relationship of the controller with the object it controls.

Embodiment in the first sense, the role a system plays in the space and social context it is deployed in was observed to become gradually more important for the user group over the 6 months of use. The fact that this was an actual object that they could control in the space they worked in was steadily more acknowledged. The telepresence receptionist became part of the day-to-day

context. The users appreciated its physical appearance, the fact that it was a kinetic object that played a functional role in the reception space. In this respect the experience of the system was like 'a robotic extension of a colleague'. This is underpinned by the fact that they nicknamed the receptionist with the name of a colleague that was frequently visible on the screen.

The more direct experience of embodiment: 'looking' left and right by manipulating the controller left and right became more of a routine. Users commented positively on it and in the first weeks used to play with this functionality. When the novelty effect had faded, users applied it when appropriate. One user was observed referring to panning the screen as 'looking around': let's have a look at the other side'.

In general, I argue that the embodied quality, the representation of a real receptionist and the functionality of the system, had a positive effect on its use. The fact that this was not a platform based, generic computer application, performing all kinds of daily tasks, but one piece of equipment that had one quite basic function and was appreciated as a visible addition to the toolbox of the team.

### **8.3.5 Modular, off-the-shelf components**

The choice of off-the-shelf components allowed a more flexible design process and the possibility to adjust the design, also just before the system was actually deployed. As mentioned before, the use of these parts often results in a trade-off between feasibility and aesthetics. Off-the-shelf parts are often clunky, generic and on first sight not very well designed. Because we focussed in this study on the design of the interaction and less so on the aesthetics, it usually did not interfere with the evaluation.

On the other hand, some of the users commented on the aesthetics of the system and said they would have appreciated a more bespoke, more elaborate, subtle design. The experience of a system cannot be seen apart from its aesthetics. It can be argued that conjoint control is an approach to design interaction but should be followed up by a cycle where the results of the conjoint control cycle is translated in a better, more aesthetically designed system.

### **8.3.6 Soft implementation**

One of the major distinctions of conjoint control is that it allows the end user to become acquainted with the system over an extended period of time, in a safe environment. During this period, the user can give feedback for final adjustments to the system.

Our users appreciated this period and indeed gave input, even participated by designing new graphics for the telepresence screen asking visitors to ring the bell. The relationship I built with the users lasted throughout the 6 months of the field trial, and resulted in a pleasant, professional cooperation.

I argue that this approach where end users are part of the design process can not only lead to a high acceptance rate, but also definitely to a better, more precisely adjusted design.

## **8.4 Future work**

In this study I focussed on the design process, the implementation and use of a telepresence system with simple control for a relatively long period of time in a real-world office context. The telepresence receptionist was built of off-the-shelf components, with open source software platforms. This allowed a flexible design process where the input of users could be followed up on relatively quickly. This concept: flexible, modular designs to facilitate a more user-centred design process, in my view has potential to be followed up on.

In this respect, this study also highlights the possibilities the thriving maker culture provides individual users. The potential of this way of empowerment, where communities of 'makers' collaborate to provide users with individual needs and wishes, has actually not been exhaustively explored and deserves more attention and effort.

As a result of this study, further study of what I call deployment strategies for controllers is appropriate. Initially intuitively, I applied what I called a soft implementation phase in my study: a relatively long and playful period in which the user can familiarize herself / himself with an application and the way to control it. Arguably, this can be an appropriate alternative strategy to make

users accustomed to fewer generic interfaces. More in depth study of this and similar implementation methodologies have the potential to support the acceptance of novel interaction models.

Simplicity in human computer interaction is a value in itself. Users in my study comment on the complexity of everyday systems and the time and energy it takes to master them. They also report on the negative experience of the generic systems in the workplace. My study indicated that the approach I call conjoint control can be an option for study in specific use cases, not especially as a more effective solution for all appliances but surely as a more pleasant, wholesome experience for the user.

## **8.5 Conclusion: a new strategy for the control of simple systems**

This study explicitly focusses on simple interaction models, on controllers of systems like remote controlled cranes or, in the case of the system I built for the field trial, the control of remote collaboration tools. Recently, there has been increased attention to these online interaction models.

Simple controllers for everyday functions in more specialized user contexts not only have the potential to be faster or more pleasant but also a safer, more practical solution. Exploring technologies, combining old and new interaction models, assessing without beforehand disqualifying them, can be a productive strategy for future developments. Especially now the world relies on online interaction for many vital functions, it makes sense to rethink the models that are applied so far.

Computers, in many forms, from the automatic washing machine to tablets, have developed into a determining factor in our everyday lives. The way we interact with them though, has not developed accordingly. We still use computers with rather uniform interaction models that were invented more than 50 years ago. A good example is this thesis: I used roughly the same application and exactly the same interaction model to write it as I did more than 3 decades ago, writing my master thesis on my Atari 1040ST. It is safe to argue users deserve a more up-to-date, differentiated, healthier and more pleasant interaction, a design for the body and from the body as Kristina

Höök<sup>77</sup> argues, applications with intuitive, physical quality. This implies a considerable challenge for developers. Interface design is usually inclined to follow the more rational interpretation of interaction, and the body is seen as a quantity that can be modified or even neglected, a '*quantité négligeable*'. The advantage of such a paradigm shift is that our physical abilities can be relatively generic and, although undoubtedly also socially determined, have the potential to address large user groups, in many classes and cultures.

I argue that the approach I present in this study that I call conjoint control, a user-centred approach, in a flexible design process, applying a modular structure with affordable components, for a limited set of functionalities, designed and deployed in a collaborative process, has the potential to break boundaries and can be applied in a number of contexts, whatever the background of the user. In my perspective the generic user does not exist.

Almost everybody uses a 'special' application, whether it is for health reasons, or for professional use. Users can control systems temporarily, after for instance a severe accident or for the remaining part of their life, when they for instance develop a chronic disease. There is such a variety of novel applications, of small scale adaptations of existing technologies and interaction models, that there is still a huge playing field for tinkerers and designers to join forces and creativity to develop novel interaction models for new or not so new applications.

My field trial showed that the users of the telepresence system appreciated the controller, even though some experience it as not more practical or effective than a generic interface. Users apparently do not specifically want to only be effective, they want interaction with their everyday, professionally or privately used, applications to be clear and pleasurable. Users are entitled to digital applications that are a helpful addition to their workload instead of an extra stress factor. In this respect I am convinced that the HCI community has ignored some of the obvious intrinsic qualities of the concept that has been there all the time in plain sight: the low hanging fruit of very straightforward interaction. Simple control of everyday functionalities: buttons, switches, sliders, knobs and of course bespoke controllers, have the potential to couple the bits to the world around it in an outstanding way.

There is a world to win in the design of simple controllers that can perform relatively complex digital tasks. There are developments indicating users do not accept the limited array of interaction models the mainstream tech companies are offering. In the audio / visual sector for instance, professional cameramen pay extra for cameras that have large, easy to manipulate buttons instead of a small touch screen with menus. Studio equipment with GUI interfaces are replaced by video mixers with buttons and sliders. This is not a development back to the studio-technology of the last century: the functionality and work flow of audio / visual equipment nowadays are completely different and advanced, with built-in effects and colour correction et cetera. It is the realization that too much functionality does not necessarily improve the quality of the interaction and surely not the end result. A simple interaction model allows the user more time for their core business.

This thesis resulted in the design perspective I call conjoint control, an approach for specific contexts, designed in a collaborative process. But to implement such an approach, a change in attitude in the industry and design community is needed. Interfaces in general are likely to be the balancing item in a design and production process, rather than an integral part of the application. The accepted idea seems that any form of control other than a simple GUI is more expensive and needs a longer, more elaborate design process. Assuming that this is true, there still are obvious contexts where conjoint control can facilitate functionalities more efficiently and provide a better experience. The question is: where are the opportunities for conjoint control and how do we implement them?

One of the answers might be that digital applications are seen more and more as a stress factor in our daily lives<sup>186</sup>. The concept of calm technology, that was one of the inspirations of this study, addresses that users should be able to differentiate between functionalities in the periphery - in the corners of their eyes - and the centre of attention, allowing a smooth and calm interaction. From a contemporary perspective, not having to use technology is sometimes seen as a privilege, reserved for the well-to-do. To be able to lead our lives without having to squint behind a screen has become a luxury. From this viewpoint, the perspective of conjoint control not only has opportunities in the realm of bespoke, specialized applications in for instance the audio / visual or health domain designing bespoke applications for challenged people, but also

at the higher end of the market, for more sophisticated applications like domotics. The control and automation of applications in the house, like blinds, heating or audio / visual equipment. I can imagine nicely crafted controllers for the operation of a home cinema or a beautiful interface for the heating or air conditioner.

Yet, there are also inspiring examples from the industry where a tangible approach delivers a better experience in a contemporary context. Nintendo introduced in 2017 Nintendo Labo (see Fig. 56), for the Nintendo Switch gaming computer, a variety of tangible control added to the game tablet, providing a different experience. The consumer is required to build the tangible augmentation herself, providing a readymade DIY / tinkering component to the experience. As pointed out by Fujimoto<sup>187</sup> this initiates an interesting paradigm shift where the tangible element augments the screen based digital device. This might be a promising direction, where the GUI platform is actually aided, restricted, or otherwise augmented by tangible additions.



**Figure 56: Nintendo Labo project.**

In 2016, Microsoft launched the Microsoft Surface Dial<sup>188</sup>, which can perform different tasks connected to the Microsoft Surface Pro. It is hard to assess what and where the dial has a strong use case, although it is still on the market. It might be an indication though that the computer industry is still looking for ways to insert novel ways of simple control in their interface models.

It requires in my opinion a more generous, but also a practical view on interfacing models to move the field forward with the considerable force that is



needed to really make an impact. The applications mentioned above are generally simple and they combine technologies: augmented projections, e-ink or the combination of game controller and wood / cardboard add-ons.

In my perception, in our ecologically challenged times, it is the task of interaction designers to be a guide in our relationship with technology. Designing quality that can withstand long term use is not just a feature anymore, it is a number one requirement. I am convinced the design of controllers is one of the important strategies to design sustainable interaction models. Interaction that is tailored to the entire spectrum of senses and skills of the user is in the long run more wholesome and efficient and a set of healthy users together makes up a healthy society.

Humans possess wonderful tools, we are remarkably well equipped for hybrid interaction. Our ratio, our intuition, our senses and our physical abilities: they comprise a very advanced system. To ignore one (or more) of these abilities when designing human computer interaction is not sensible and certainly not productive. To design pleasurable interaction that connects both those high-end systems: our human qualities and technology, in my opinion, is one of the big challenges for HCI for the foreseeable future. With this thesis I accept that challenge.

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# **Appendices:**

## **First series of interviews user group PROTO**

December 2018

Telepresence receptionist first series of interviews  
December 19, 2018

A: positive attitude towards technology, regular user

SN: Can you tell me a bit more about the system as such: how did it come across, you had some reservations I remember, when you saw it for the first time?

A: Reservations? did I? I can't remember that but maybe I was playing devil's advocate, to question it and find out whether or not it was right for us (M. is general manager and responsible for the experience of PROTO) I have been impressed with it, I was not sure what it was going to look like, maybe that was my reservation, but I like how it looks, i like the bell, it gives it an authentic, sort of hotel bell feel, you know. I like that it has a large screen so it's clear for people, customers, that's it's there, there is a face there, you can't miss it. a positive first impression, I suppose

SN: How do you look back on the test with VERS now you've used it for a month? A: I remember thinking the technology side of it is great, but the wires on the back, they at some point need tidying up. A cover or something like that.

SN: How does the use of VERA influence the other work that you're doing?

A: I suppose it can be a distraction when it's on. Because you're constantly aware of what is going on at the other end. But for me it's different, because I'm not a receptionist, I just cover when we're understaffed, so I have lots of other work. Anything at the reception is a distraction from my other work. I just get on with it on any computer. So that's not relevant, i think it's probably a good thing it's a distraction, I'm responsible for the runnings of both receptions so I like that receptionists are aware of what's going on here. I like the fact that I can spin it around and make sure I haven't missed anyone or just check if anyone is not doing things that they shouldn't in reception. And I want the receptionists to use it.

SN: So you can monitor the space?

A.: Yes, I do find myself using it for that

SN: How does the use of the wooden ball feel to you?

A: Fine, sometimes when you spin it quite a lot it does not stop, but I suppose you have to learn to work with it. - We can make it less sensitive. No I think it's getting used to I suppose it's just fine the way it is.

SN: How do you feel about talking to 'the other side'?

A: Talking to the other side? I have no inhibitions, but I notice some customers do.

SN: What can we do about that?

A: I actually don't know if anything you can do makes a difference. You could put a sign at this end (the other end than where the screen is positioned -SN) saying talk to intercom, but I would not know if that would make any difference.

SN: What do you think can be improved about the way the system is presented to you and the visitor, is the bell used at all?

A: Do people press the bell? do they use it? yes they do. I think so. But if they miss it, I'm always looking whether or not there are people that are looking lost, monitoring.

SN: So that works for you, I always say it's like a window, to the other side...

A: Yes I like that. I honestly don't know what could improve that. You're always going to be talking to a screen, so when that's what is putting people off, I don't know what could help that. maybe from the other side, when you would have a scripted scenario for the receptionists..

SN: Are there other things you use the telepresence receptionist for than the welcoming of visitors -banter/talking to colleagues, monitoring the room etc.-

A: I've never pressed the bell, other than to get for instance Raegan's attention. I also used it when people come in and just sign in on the list that's on the desk, I just press the bell and ask them what I can do for them.

SN: Did you get used to using VERA?

A: Got quickly used to Vera, but the turning on and turning off sequence is complicated. There's nothing very onerous about it. We never have to go into the inner workings of the system.

SN: About the red LED button that indicates whether or not you're audible - and visible- at the other side, can you tell me a bit about its use in practice?

A: Red button: was it clear? I asked that question quite early on, you know privacy issues etc. (Matthew shut the system off during stress tests because he did not wanted to be listened to -SN). Yes but actually, it's great, you can still hear and see what's going on from the other side but shut down your end of the system so you cannot be heard.

SN: Where can we improve the system?

A: There's nothing wrong with the system as it is now but I suppose having it on constantly would be better when the system is off, the screen would communicate a certain message. When the system is off now, customers see a black screen. And I don't know what that does to the customer: do they wonder what to do with it or don't they even notice it.

-showing video's or a different message o the screen when its not in use would that be a good option? I think so

SN: How can we add new functions to the controller (like opening doors, scanning mails etc.)?

SN: Do you have suggestions for the design of the controller?

E: I like the design of the ball. It's nice and simple to use. The first time I used it I thought it had a bit of a joystick functionality but now I know how it works, it's fine..It's nice and easy SN: do you have suggestions for the design of the system as such (not how it looks)? E: Other than tidying up? No, I don't think so. It's a good tool for us and I like to use it, it's fun to see people amazed that there's a piece of tech that is really functioning.

Telepresence receptionist first series of interviews

December 19, 2018

B: not tech savvy, regular user

SN: Can you tell me a bit more about the system as such: how did it come across?

B: I'm not a tech savvy person so it was quite daunting at first, using it a couple of times it was impressingly simple, how to start it up, how to operate it, how to physically speak to people, the sound, I had no issues with that.

SN: how do you look back on the test with VERA now you've used it for 2 months?

B: Positive

SN: How does the use of VERA influence the other work that you're doing, is it a distraction?

B: Not particularly, it's no additional sort of workload.

SN: How does the use of the wooden ball feel to you?

B: I quickly picked that up because it's quite sensitive, you cannot stop it once it's going. I thoroughly enjoyed using it, actually.

SN: You enjoyed using it?

B: It's just been helpful, when we're short (of staff -SN)

SN: And specifically the ball?

B: Again it's just sort of straightforward.

SN: How do you feel about talking to 'the other side'?

B: I think it's an overwhelming sort of response of people when they realize they're talking to somebody. But it does not change much, you're just still be able to help them. It's been great actually.

SN: What do you think can be improved about the way the system is presented to you and the visitor?

B: I've been genuinely thinking about that because I was expecting such a question, but honestly, nothing comes to mind.

SN: Do you like using it?

B: Yes, absolutely.

SN: Are there other things you use VERA for than the welcoming of visitors - banter/talking to colleagues, monitoring the room etc.-

B: I use it to just look whether or not somebody is inside (monitoring the space -SN)

SN: Did you get used to using the telepresence receptionist?

B: It's yes, we have plenty of staff but there are days when there are for instance events going on and we would have to run up and down so it's been a particularly good piece of equipment.

SN: Is it a pleasant surprise for the visitors at this end?

B: I think they are surprised how straightforward it is. We've had council members and press and they are pleased. We're still able to give the information as if we would be there, so that's good.

SN: Can you describe your learning process mastering the telepresence receptionist and the new joystick interface?

B: I think at first, at the first training session, it looked like it was more difficult to use than it really is.

SN: Can you tell us a bit more about the new control: was it self-explanatory, or did you need instruction?

B: It was fairly straightforward, the LED button, the bell, it's little quirks like that that were picked up fairly quickly.

SN: Was the ball shaped interface easy to use, as it's bespoke and must be new to you, was it easy to use?

B: Fairly easy, straightforward, yes.

SN: It does not flip back to a neutral position, how was that for you?

B: That's been particularly good, especially when you're scanning the space, when there's nobody there. To see if somebody has for instance come in by mistake and is wandering up there.

SN: About the red LED button that indicates whether or not you're audible - and visible- at the other side, can you tell me a bit about its use in practice?

SN: Can you tell us how you boot up the system, did it give you any trouble?

B: In the beginning: yes, now I know how to start it: first the PROTO end then the Baltimore House.

SN: Where can we improve the system?

B: I suppose in the beginning, the first one or two times. Now we're used to it. So when A is going home early, we're happy to boot it up. It's that flexibility that's good.

SN: How can we add new functions to the controller, user scenarios like opening doors, scanning mails etc.?

B: I can't think of anything that would sort of improve. The only thing is that when we want to put it on last minute, it takes some time to start up. No negative feedback, I've been enjoying it so far.

SN: Do you have suggestions for the design of the controller?



B: When people are using it for the first time, it might be a bit (uncommon - SN), that's what I've noticed.

SN: So you agree that the red LED button might be a bit clearer?

B: Yes, when you're busy, you might overlook it.

SN: Do you have suggestions for the design of the system as such, how it looks, the wiring for instance?

B: The wiring, yes that's the sort of thing, purely aesthetic improvement.

Telepresence receptionist first series of interviews

December 19, 2018

C: not tech savvy, regular user

SN: Can you tell me a bit more about the system as such: how did it come across?

C: It looks more complicated than it is but it is actually easy to use.

SN: How do you look back on the test with the telepresence receptionist now you've used it for 1 month?

C: It's good, it is nice to use and it looks good. What you would expect in a reception at a technology centre.

SN: How does the use of the telepresence receptionist influence the other work that you're doing?

C: It does not distract me at all. Not more than that I would be sitting at a reception. And I'm used to it now, it's fine.

SN: how does the use of the wooden ball feel to you?

C: Most people are standing in front of the screen, so you don't really need it then but if you're directing somebody, then you would use it. And it's absolutely fine to use.

SN: Does it feel natural to you?

C: Yes, definitely.

SN: How do you feel about talking to 'the other side'?

C: I feel totally fine doing that because you can obviously see them so it's just like being face to face.

SN: What do you think can be improved about the way the system is presented to you and the visitor?

C: The wires need to be tidied up. And covering up the back of the screen would be good. It really looks like a prototype now and that's fine, it just looks better when it's covered.

SN: Are there other things you use the system for than the welcoming of visitors -banter/talking to colleagues, monitoring the room etc.-

C: I definitely have conversations with D through it. But not often, like, we only turn it on if we actually need to use it.

SN: did you get used to using the telepresence receptionist?

C: Yes, I definitely got used to it, it does not take long to get used to it and I like it, it is cool to use it, to see people surprised by you on the screen helping them.

SN: Can you tell us a bit more about the new control: was it self-explanatory, or did you need instruction?

C: I would not say it took me long to get to know how to use it, you know. But you definitely need the workshop, also the turning on process, you wouldn't know how to do that otherwise. But once you know it, it's easy enough to use.

SN: About the red LED button that indicates whether or not you're audible - and visible- at the other side, can you tell me a bit about its use in practice?

C: If you've done the workshop you would know. You might forget from time to time but then you realize how to use it.

SN: Can you tell us how you boot up the system?

C: No problems with the booting up: after a while it's simple, it's not a nuisance at all.

SN: Where can we improve the system?

C: It would be nice if you would be able to start it with one button.

SN: Maybe a signal to show the system is open at both ends? That's what E suggested.

C: It's not in your face the red light, that's right. Maybe a bit bigger but not too big. It is clear as it is, anyway.

SN: Do you have suggestions for the design of the controller?

C: Anyway, the controller is well designed, it looks cool, i could not think of any other way it could be better..

SN: Do you have suggestions for the design of the system as such (not how it looks)?

C: I don't know if I have any suggestions.. it's positioned well..

SN: E also suggests an extra sign to make visitors aware of the system.

C: Yes, that could be, a good solution. But I don't know, it is clear as it is and visitors that don't want to ring the bell don't, anyway.

Telepresence receptionist first series of interviews

December 19, 2018

D: tech savvy, not a regular user but interested in the system, the first person users turn to when it malfunctions

SN: Can you tell me a bit more about the system as such: how did it come across?

D: First reaction: very straightforward, I had some problems with booting up system. Bit fiddly when it did not connect straight away once it's up and running it's fine

SN: But you did not have to go into the system to fill in another ip address

D: No we did not have to go that far.

SN: How do you look back on the test with the telepresence receptionist now you've used it for 1 month?

D: First impression is positive. If the system works as it should do, it should actually help out quite a lot, so if someone's sick or on lunch we use it and it has helped quite a lot. It could be designed a bit friendlier.

SN: "How?"

D: The bell could be made more visible, or it could be more obvious what the bell would do -maybe a video on the screen.

SN: How does the use of the system influence the other work that you're doing?

D: It's fine once the system is running, it means that we, well myself mainly, can get on with other tasks, I don't have to focus too much on reception, I can trust that E is on the other end.

SN: How does the use of the wooden ball feel to you?

D: The interface is a bit too fiddly

SN: Would you say it's too sensitive?

D: Yes. Maybe you could design feedback, a clickable ball

SN: how do you feel about talking to 'the other side'?

SN: what do you think can be improved about the way the system is presented to you and the visitor?

SN: are there other things you use VERA for than the welcoming of visitors - banter/talking to colleagues, monitoring the room etc.-

D: Yes, when I'm here and the other side is active, i just holler to them or ring the bell for support from for instance E

SN: did you get used to using the system, was it a help?

D: Yes. Not necessarily for me but for the team at Baltimore house. But now I come to think of it also for me, it means I don't have to bother as much about reception as much, with lunch covers

SN: Can you describe your learning process mastering VERA and the new joystick interface?

D: The learning process? (laughs) Fairly quick I would say.

SN: About the red LED button that indicates whether or not you're audible - and visible- at the other side, can you tell me a bit about its use in practice?

D: The red button is good, it clearly indicated whether or not you are live, you get direct feedback on that.

SN: Can you tell us how you boot up the system?

SN: Where can we improve the system?

D: In my opinion you could make the ball less sensitive, if you turn it slightly, the screen rotates quite a lot

SN: But is the rotating of the screen is helpful as such?

D: Yes, it means that if you have to direct someone to a certain place, you can use it meaningfully, look the visitor in the eye, that really works.

SN: How can we add new functions to the controller (like opening doors, scanning mails etc.)?

SN: Do you have suggestions for the design of the controller?

D: Possibly a little image, below the button, the led button to see more clearly when you are live,,

SN: But also the ball?

D: It would help to have a little indentation so you could see when its back to zero

SN: Do you have suggestions for the design of the system as such (not how it looks)?

D: No it is fairly alright: it's open from the receptionists end so you can listen what happens. There are maybe privacy issue but on the other hand it's nice to be able to know what's going on at the other end for security reasons. In general: the system could be more designed: with a cover on the back it would look a lot nicer, on the front the speaker could be more implemented in the design. Also, it would be good to make the system easier to boot up.

Telepresence receptionist first series of interviews

December 19, 2018

E: not tech savvy, regular user

SN: can you tell me a bit more about the system as such: how did it come across?

E: It's not really hi-tech, but that's a positive, I suppose.

SN: How do you look back on the test with VERS now you've used it for a month?

E: It's really simple, but what I've noticed, when people come in they don't know where to focus, how they're visible on the screen.

SN: Are you aware how you look to the other side?

E: I have the feeling I'm too visible, I don't know why people have to see my whole body.

SN: You can get closer to the camera and people will only see your face.

SN: Can you describe how long it took to know how it worked?

E: Not a long time, it is pretty simple.

SN: The red button for instance, how did that work for you?

E: The PIP could be a bit bigger so you can see how and when you're visible.

SN: The red button could be more prominent?

E: Yes, bigger and for instance flashing on and off. Just when people are asking attention, you want to quickly assure from the corner of your eye whether it's on or off.

SN: Can you tell us a bit more about the wooden ball? You said before it's very sensitive.

E: It is.

SN: Did it make it harder?

E: No, it's just remembering it's very sensitive. When people are walking in and out. It is hard sometime to get them in the image.

SN: The booting up of the system, how did that go for you?

E: It's fine, they just boot theirs up and then I'll do mine.

SN: How do you communicate about starting the system?

E: We just ring up. Would be nice to have a signal to know that theirs is on so I can start mine. It's just time management: I wait for them to turn it on and I get distracted.

SN: How does the use of the telepresence receptionist influence the other work that you're doing?

E: It's a distraction sometimes, when you're doing other things, but I personally don't mind.

SN: How does the use of the wooden ball feel to you?

E: It feels good, it's very sensitive but I'm used to it now. It looks a bit odd, but I like it now.

SN: how do you feel about talking to 'the other side'?

E: I feel ok, but I notice people are startled sometimes when they see me all at once. Surprised.

SN: What do you think can be improved about the way the system is presented to you and the visitor?

E: It does not look very hi tech at the other side.

SN: But should it look Hi Tech?

E: I think it should. Not so much for this building, but at PROTO, it should be all VR and such.

SN: Do you have overall suggestions for the system, other user scenarios?

E: For the sound it would be good to see the volume on the screen. Now you just use the button and you don't know how loud it is. There's so many wires on my desk, I sometimes get confused. It would be good if all the electronics were integrated in one big system.

SN: Are there other things you use the system for than the welcoming of visitors -banter/talking to colleagues, monitoring the room etc.-

E: No, usually not, because you can't know who's listening in to the conversation.

SN: did you get used to using the telepresence receptionist?

E: I did, it is simple, straightforward, but I tend to forget things once I haven't used it for some days. Like the bell, or the LED button, it takes some moments to realize how it all works, because it is kind of uncommon.

# **Second series of interviews user group PROTO**

May 2019



Telepresence receptionist second series of interviews

May 20, 2019

A: positive attitude towards technology, regular user

## INTRODUCTION

SN: So can you tell me a little bit about the system?

A: Yeah we use it as a we call a virtual receptionist and we use it as a way of running two receptions at once. We've got slight staffing issues at lunch times and when people are sick or on holiday so it's handy for us to be able to man one reception with this PROTO reception and the person at the Baltimore House reception. It just helps us to manage our staff much better so it's very good in that sense that it just we were able to kind of be two places at once. From a functionality point of view it works well it's very simple for the tenants and the visitors to the centre, they seem to be able to use it use it well and we can respond to that, talk to them on our end no problem so from a functional point of view it seems it's all fairly straightforward and just what does is it should.

SN: This is just an inserted question: you've used it for four months and I've noticed it also maybe it's me but it looks like it's become busier, did that have any repercussions for the use?

A: The building is becoming is busier than it was four months ago, but I wouldn't say that we use the system a great deal more. It's just when we need it really and it's more to do with our staffing needs, more than how busy it gets because also if we've always got a staff member there we use the staff member first (instead of the VERS SN), I suppose we use it as a kind of a substitute, just to help us really and yeah but it is it is getting busier so more and more people are using it.

SN: And does it influence the other work that you are doing so for instance if you're there you know that you can use the system you take other work with you for instance?

A: I wouldn't say necessarily influence it, I suppose what I can do is, if it's me who's using it, personally I'm not a receptionist but I obviously do cover (for others at both receptions SN), if it's me who's on there I will always take my work with me so it does allow me to do in a way three jobs at once: my own sort of paperwork and financial stuff and invoicing the things like that but (I can work on SN) a computer screen and at the same time man the reception so that's great for me.

SN: because you're the manager

A: Actually yes of the two buildings both, so (PROTO and SN) Baltimore House

SN: Yes and you've now used both of the of the controllers if you use the joystick

A: Yes I used the joystick

SN: How did that feel?

A: Good it's nice and smooth, it works well. The joystick is good I think I like it because I think that anybody who's sat down there for the first time, I found this myself, that anyone sitting there the first time with the round ball, you don't quite know whether you should be twisting it or moving it left to right like a joystick so I suppose the joystick is easier.

SN: That might be true because I gave a sort of a workshop for the ball interface but I didn't do that for the joystick.

A: And it seems to be smooth and you know responds well it the camera response to it instantly

SN: And how do you feel about talking to the other side because you used now two systems: you use the separate microphone but with the other interface with the joystick interface the microphone is on the tablet. Did you notice any difference?

A: I haven't noticed any difference you know, the sound is fine the audio is always good, when it works, it works well.

SN: And what do you think that can be improved about the system is it the way it's presented to you?

A: Presented? I suppose nothing on this side (client side, where the real receptionist is SN) on the other side I suppose we could do something to tidy up the back in case the wires. From just how it looks I suppose you're working on that now so I think it just needs a cover or something to make it a little bit more you know (presentable SN) and I suppose you'd probably say it would look like a prototype in the sense that the wires are exposed and I suppose (it's practical for SN) maintenance obviously. There's been a few instances where we've had issues, I don't know about what any of those issues were..I think the issues were that the IP address was changed.

SN: Well there was an IP issue but also the other issue was that we just implemented the second interface without properly testing it so the other interface, I don't know if you remember that before we started I mean before you guys used it, we did a stress test for more than a month that really tested the system and how it behaved and we didn't have the time or the opportunity to do (that this time SN) so well actually it's my mistake because I should have made two of them at the same time. That's actually a good point.

A: I mean you know it came at a time when we were fully staffed so we were fine so no made no complaints it's fine: we understand, it was just worth mentioning that was all.

SN: Yes because also after August the system has to be ready, the coverings have to be there and it has to actually be bug-free so you can use it alright and you can also change the interface possibly - without me (helping SN).

A: Well that would be good, that'd be great if we can do some basic kind of maintenance ourselves, well I mean if there's not a real problem as long as we keep it at Baltimore House.

SN: I think we can then more or less design it in a way and just fix the box and then it will be stable but the problems come when you want to install it some somewhere else right and that's what we do for the next generation: this will make it accessible for Wi-Fi but that opens a can of worms.

(explanation about WIFI and the system SN)

SN: Did you get used to it (the system SN)?

A: It's quite easy: the new interface once we've got it on and everything it's just it's very simple which is no problem because that's what you want from technology isn't it? I personally struggle sometimes with technology. I actually think, from a user point of view, some technologies are getting harder to use. I think you need to know quite a lot to even go on an iPhone like for us to give it to my mom she'd be like: 'what is syncing?' and things like that. I think it's getting quite difficult and we've got an example of a presentation system in the hall at PROTO and Luke, our technician here, and myself and Alex could not get it working and we just I think from a user point of view you want to be able to just use technology in 2019 and it should be very very simple. This is system works when switched on and it's simple so that's good for me.

SN: Yeah that's the central idea of this thing: it's simple and tangible and it's not an interface with a mouse where you click on (the icon on SN) the screen but just a button. So do you have the feeling that you have control?

A: Yes, the mastering of the new joystick interface went very smoothly, I didn't need instruction you already told us that.

SN: That's interesting because the red LED button of the new interface (sometimes had issues): when you press the button the videostream doesn't always come on.

A: I think straight away you said to press it firmly. For me personally: when I see that the red button isn't lit up so I press it again

SN: The issue was that even when the LED's on, the connection is still closed. About the Joystick function: was it good? Did you think it was a positive addition?

A: Well it is positive, definitely positive, but I was happy with what we had already but like I said before I think when a new member of staff (would use it SN) for the first time he or she might not immediately knew how to use the ball. A joystick is much simpler, straightforward but once I knew how to use the

ball it was not a huge issue with whether it was swapped or not but yeah it just takes away that initial confusion I suppose.

SN: Have you noticed how you can you can ring the bell with the joystick.

A: With the (button -SN) on the top yes

SN: And do you see openings or possibilities for additions to the functionality, like opening doors or scan the mail or just I mean actually the whole system.

A: I've got no idea what's possible and what isn't, I suppose the slight limitations that it (the system -SN) put on us, the only area where we're not covered it is if post arrives or a delivery. Then we've got to either go there or say to them can you come to us which isn't a big problem but it's I suppose it's one of those things that there might be a solution where we can digitally sign for something on this end. I don't know but, I suppose the other thing is that to open the doors we use a completely separate system to talk to (visitors -SN) if it was somehow linked to the door entry system on a screen there or something like that it will have three different doors: the front door, the back door and the barrier and then we use a standalone system to open those so we know when they press that buzzer to come in we could talk to them on this standalone system but then so we can then expect that at some point they're gonna come to the reception because we just let them in the building, they're gonna press on the buzzer yeah so I don't know if the scope in the future to possibly tie the two in at any point if that's possible.

SN: I think an integrated system, I don't know but because I see you sometimes and I admire you're working especially Lesley so she opens the door, listens to people etc. etc. Actually you have three or four systems, separate systems so you have a system also for the doors downstairs.

A: Yes I wonder if there was ever a chance, maybe if we had it (the telepresence receptionist -SN) switched on at all times. Because now what we do is we'll pick up the phone if somebody wants to go on their lunch break or something and we need cover, they'd have to pick up the phone (to tell each other to switch it on -SN). Is there a way of to boot both ends up from one side? So it's a flick of a switch rather than a couple of minutes to boot up do

you know. I mean maybe if we had it on from the morning would work like that wouldn't it?

SN: Yes that's a good point: so more integration and simpler to start up this actually just one button started

A: The one button started I suppose, which would be good it's not an issue though I'm just trying to work on think of how it would be better.

SN: And the design of the control or what you think is what's better what's it what you think will be used in the future the ball or the joystick?

A: Probably the joysticks more user-friendly do you know what I thought of though a thought of like and when I was a kid playing on like an Atari or an Amstrad computer you know I don't know if it's like not matters but I'm just wondering like is it like an older kind of skill that you've learned

SN: The joy stick you mean

A: A joystick that's what made me think uh yeah it looks a little..

SN: Because it's a little joystick not some one of those bigger

A: it's not a criticism of it I'm just wondering it (the joystick -SN) makes it look less sophisticated. I know that it's not I'm just trying to think of how someone might view it if it was on the market or something you know yeah I like the joystick but that's kind of what it's built in my head straight away it was like something do you know what I mean

SN: Finally do you know you if you have any other suggestions

A: For the system I don't think so, it works very well for us I have to say, when what you know and when we use it, it provides a good solution. Just like I said before it's obviously a lot of work for you but to have the ability to somehow dealing with the post would be good. And a link to the other doors. Potentially also a way of simply booting up the system. And a way of letting each other know, a signal, that you've gone on a break now so can you cover without picking up the phone.

SN: Maybe a messaging also - one from one side to the other side yes being able to edit the messaging board would also be good.

A: Right.

SN: So if there is something for instance if you have a big presentation in PROTO, you can just say there's a big presentation at the PROTO hall

A: ..rather than pressing on the button, I think it would actually be good, because we do stick signs up now, on the screen would be a lot better.

SN: I think you could use the screen more for just general notices.

A: Well yeah it's good we I like it it's a good addition, it's helpful when we need it, it's definitely helping. There was a day two weeks ago, Reagan and Rob both phoned in sick you know on the same day so you know that could happen at any time..

SN: And then you go sit you sit here.

A: Really to do and well I did that one next door but then you know with breaks and things was nice to know (you have back up -SN)

SN: What do you think of the video quality have you ever had freeze frames?

A: Actually no I've never noticed it freeze frame personally so we got that side of its always been okay we've had little instances where once I couldn't hear the other side but the video has been fine.

SN: Good.

A: I like, I've been using it when I sit here and I'm by myself. I like to have the camera switched on so that I can see what's going on next door just for comfort in case someone doesn't see it and press the button. Just to know that nobody's kind of just hanging around looking for anyone, no one's lost you know, nothing's going on in the building when it's not manned and also security reasons.

Telepresence receptionist first second of interviews

May 20, 2019

B: not tech savvy, regular user

## INTRODUCTION

SN: You've used the system for four and a half months can you can you tell me a little bit how more about how it comes across now and what you think about it after you've been using it for more than five months

B: I think it sort of developed. It's definitely been useful and used more often and we've definitely got more familiar with the system including the new changes in terms of the design as well so it's been a particularly useful device to have actually whether it be when we're short staffed or just when there's an event on for example so yeah I've enjoyed using it and working with it so far.

SN: And how do you look back on the being a test person: actually being a sort of a guinea pig?

B: It's been quite interesting. Actually having worked between Baltimore House and PROTO anyway, it's that sort of additional, quite welcome, aid, in terms of being able to manage the two (reception desks - SN) and you'd be surprised how many times we actually had to use the (telepresence- SN) receptionist to sort of man both ends. The tenants as well as we enjoyed it.

SN: Okay and how does the use of the system influence the other work that you're doing?

B: Yes, usually it does allow you actually just to carry on with your work as normal because the options allow you for example to hear what's going on at PROTO. So you know maybe someone's about to approach the receptionist, as well as that you can sort of still see people in and around the reception of PROTO so when you're at Baltimore House and the telepresence receptionist is on, you do still feel like you can just sort of get on with your work, as normal, which is a Beat help. Instead of running between the two (locations SN) and sort of making sure everything's all right, nothing's not working anything then it's particularly useful.



SN: So you feel you can you can you can trust it also you can because it yeah let's be frank sometimes it didn't work so you were really part of the test so sometimes you must have been disappointed..

B: After the initial IP address issue that we had I think it's being Beat actually. It has been really interesting to have been part of this and sort of find that there are any issues with it as well but it has been a particularly useful experiment and hopefully one that we can sort of use going forward in terms of manning the two centres.

SN: And how does the ball-shaped interface feel to you now that you've used the other one

B: It's still usable but possibly quite simplistic in terms and when comparing it to the new one. I personally I'm used to the new sort of controls now. I mean the ball control was fine by all means but yet it's we used to the new one now and that just seems..

SN: Because I replace it with the ball now.

B: That's fine.

SN: But how do you feel about talking to the other side? has that become more normal to you?

B: It was quite a novelty at first to see either yourself or one of your colleagues like really close up on the screen have to talk to them over that but I think it's second nature now I know the tenants in PROTO anyways so you know there's no sort of issue with being able to talk to them and they know how it works as well it's always been like an incredible amount of sort of interest and fascination while I've been having to us or there's being people visiting so this never felt like an issue with that especially now like we're more comfortable with the process of the system as well oh it is really nice to a year

SN: And what do you think that can be improved about the experience of the system about what about its functionality but about how it looks and what to look and feel?

B: So maybe the way it is designed (-can be improved -SN). I think the audio was always very good actually. Just aesthetically the back of the screen could be improved. That's possibly the only thing I could think of but I know that sort of in hand anyway

SN: It has to be very lightweight because in the weekend I tested a plastic right but actually it was too heavy it was - yeah it was affectation I just didn't feel sure about it but it was - it just - so now I'm actually I'm going to print a very light weight or foam with slits in

B: So yeah so it's not the only I can think of first ever was found the sound to be excellent the quality of the camera as well so always been really good so.

SN: So you don't you haven't experienced any freeze frames or..

B: No I'm familiar with the sort of the speed of the rotation as well and I can say the sounds always been like really good, the quality to see from Baltimore PROTO as well, when you're using it or you're operating it so it's been mitigated

SN: So you've been using the wooden controller, then you used the joystick, now how did you like the new controller (the joystick -SN)?

B: I think it added something to it. I think it was just like a childhood thing like playing a computer game, with a joystick. It was slightly more enjoyable to use then the sort of original sort of device I think. I personally enjoyed it and found it easy to use as well.

SN: Are there other things that you use it for now other than welcoming guests, like talking to your colleagues or just looking around to see if somebody's there or just use it for anything else than the main uses scenario?

B: There's been this sort of occasion where we've demonstrated it to a curious tenant and we've been showing it to people on tours and then we sort of quickly demonstrate how it works. And then usually at the end of a day (we boot it up -SN) for quite a short (while -SN) when somebody is maybe nearly finished. But when people come, in particular quite important clients, we do sort of show people around and the telepresence system is one of the things

we tend to point out so we used it before (to show visitors how it worked when the system is not needed -SN) .

SN: I mean you've been using it for more than five months now are you really used to using it with you are you really would you say that you really became part of your team?

B: I'm not the member of staff that uses it the most but there is the odd time where I will be here on my own so I end up having to use it but I think it's been a great addition to the team and it's quite as sort of nice for the purpose of PROTO to have something like that on site as well for the interest and obviously the sort of the backup for us it's been a particularly useful sort of the piece of cake to have around actually.

SN: And can you describe the learning process mastering the joystick? Did that go very quickly or not, because I didn't give you any further instructions like for the other interface, because I thought it self-explanatory.

B: Yeah I don't recall having any issues with the new joystick I think this is one of those sort of once you've used it and you get familiar with how it rotates in the operation of it I've never personally had any issues

SN: And have you noticed that for ringing the bell, how that works in the joystick?

B: I think I've used it and I know sort of all the functions.

SN: The red LED button, I noticed it had issues, can you tell me a little bit in practice how it works?

B: I'm not sure if had these sort of issues, what were the issues in question?

SN: The issues I had or that this week, but that was with the joystick, were that the LED was on but the streaming was off, so i had that one time but it shouldn't happen, it is really a glitch in the hardware.

B: Alright, I don't think I've noticed that personally.

SN: The booting up of the system, the starting of the system did you get used to it? Did it get better, because it is actually the only really complicated thing in the system it you have to first start death thing over and then that thing and then you have to I think once

B: I got the hang of that like which order to put it in terms of putting it on which other intensive putting it off I'm sure the camera and the microphone one sort of right sounds as well I think once I sort of got the hang of that because I'm not the most tech savvy person ever but I mean thankfully I mastered that fairly quickly, okay that didn't personally have any issues.

SN: Where can we improve the system so the system as such or where can we improve the functionality of the of the controller how could we could be for instance add functionality, would you like it to have an integrated system where you can open the doors with one interface with one or maybe check in the mail?

B: I think it was sort of, yes it's fairly straightforward enough but yeah if it was sort of possible (to integrate functionalities but I mean it was always sort of fairly straightforward to use but if it was possible (to combine SN) in one device all of those options that would be particularly useful. I mean, apart from the phone, it was never an excessive sort of thing to have to use another handset in terms of letting people in, but combining functions in one device that would be Beat.

SN: Yes, when I see the reception desk I see a computer, I see a phone, I see the opening set with the phone, I see my actually quite a lot of stuff and I'm actually looking at possibilities for integrating that so even get rid of the computer so you can or make the system part of the computer.

B: Anything that can declutter would be particularly sweet yes.

SN: Because there's also a thing somebody proposed, just have an app on your smartphone so you can just use your smartphone when somebody would ring the bell because those are all possibilities of functionalities that you can add to your system.

B: That would be really useful, I think that would be Beat like that it's very early days in terms of the devices going forward to consider.

SN: Do you have suggestions for the design of the controller ?

B: I think in terms of sort of the joystick was particularly useful in terms of like functionality and aesthetically as well so that's great. It just looks really good I think it's sort of again as simple as possible in terms of being able to use it and to pick it up pretty quickly then.

SN: And for you for you as a person that's not really tech savvy do you appreciate the fact that it's a very simple thing?

B: Yes it has a very simple functionality: what you see is what you get, I mean there's no more functionality, there's none. It's in all seriousness the fact that it's quite straightforward is great, that I've been able to master it is sort of quite a good thing.

SN: Good to hear and do you have any other suggestions for the design of the system for its functionality, for like things that you could add, and editor for the welcome screen?

B: Personalized after the occasion up to the date or something? Either and that'd be a really good idea just so the screen can be edited just to sort of for like an event at PROTO or you know sort of maybe when we're really stretched here, when we have only one or two (colleagues -SN) in just to provide a bit of an understanding like (a message with: SN) 'someone will be with you as quickly as possible', that sort of thing like that like alterable sort of things on the screen that'd be a great start.

SN: How did you like it so far, to be involved in the project?

B: Actually it's been a great year so far it's been nice to being part of this sort of process and the trial and error aspect of it. And I appreciate saying what could possibly be added to it it's been a good time so far yeah.

SN: We were able to make something that is functional enough that it's really. Because people make lots of prototypes, but prototypes usually aren't used in a real life situation so for me this is actually the first time that I've implemented

something in a real life situation this stage of the of the design process. It's been a rewarding experience, a privilege for me to work here to be able to work with you guys as a community.

B: Yes that's how I see it, that we were a community.

SN: I'm trying to improve this thing and I hope I can get the funding and to make a next generation. That's the plan.

Telepresence receptionist second series of interviews

May 20, 2019

C: not tech savvy, regular user

## INTRODUCTION

SN: Can you tell me a bit more about you've been using it for five months what are your experiences?

C It's really good it's a really good thing to be able to use when especially when we're sure that staff allows people to leave work if the need to and especially myself which is good. But it has been really hard at times when we were short-staffed because people that way this reception can be covered so you feel more free, you feel more free to to to go every lunch break you don't have to rely on people being around all the time because we can use that instead.

SN: Does it influence your other work? So when you're using it a couple of times?

C: I think I've only used it once from the other side.

SN: did it influence your work in any way did you did you do any other work (because of it SN)

C: It well obviously if someone's covering it from the other side it allows me to do more work, definitely. So when I was doing my NVQ (National Vocational Qualification) and if I needed an hour for that, that you could put it on and Leslie could cover whilst I was doing that even though I was here.

SN: Do you also use it just to talk with each other and chat?

C: I like put it on before i'm going and I will just put it on to chat.

SN: I've noticed it's busier this year. Have you used it more than before?

C We probably have used it more than we did at the start definitely and because it has got busier especially more tenants. So obviously tenants will

often have questions so someone needs to be available for them and where I was at the start we didn't have as many tenants. But when people come, in particular quite important clients, we do sort of show people around and the telepresence system is one of the things we tend to point out so we used it before.

SN Have you used the wooden ball and the joystick too ?

C: I've used the wooden one that's the one I've used to haven't used the new one.

SN: What do you think about the wooden ball?

C: Yes it's just very straightforward very easy to use.

SN: How do you feel about talking to the other side through system ?

C It's something you just got used to like I'd be totally confident talking through it now But it's strange, isn't it, talking through that thing. But as I say, I just got used to it and I think E feels the same she's totally confident with it

SN: And what do you think can be improved about the way the system is presented to the visitors?

C: Maybe just the wiring and stuff on the back, other than that, no.

SN: Would it be a good idea to integrate all three systems on your desk: the door opener/telephone, the virtual receptionist and the computer system registering visitors?

C: Yes, that would be much better. For the next generation, having it all in one.

SN: Is the function of the LED clear to you are there any glitches?

C: Yes that's clear.

SN: And the starting up of the system, is that clear?



C: It's obviously up until last week it sort of was (there were problems with the network of the building) obviously that problems being fixed now. So that's fine now and it's very straightforward to turn it on and set-up.

SN: How can we improve to the system, do you have any suggestions?

C: I suppose just making sure it's reliable all the time.

SN: Would you appreciate it too if we added functions like open the door or scanning the mail? Would you like to be able to monitor more doors with this system. So physically it would look like the same screen as you have over there but you just see in a picture-in-picture several doors and you can just click into one door to operate it would that be efficient?

C: Yes, I think it would. be good if it was all in one.

SN: And the controller itself the ball-shaped controller looking back on was it for you immediately clear how to use it?

C: Yes, I think it was. Definitely yeah it's because it's just a pretty straightforward shape and when you move it it is instantly clear how to use it.

SN: And do you have any suggestions for the design of its controller?

C: No one thing quite I like it the way it is I think it's yeah and I don't think it could really get any clearer how to use it the way it is.

Telepresence receptionist second series of interviews

May 20, 2019

D: tech savvy, not a regular user but interested in the system, the first person users turn to when it malfunctions

## INTRODUCTION

SN: It's a bit like the last time: a semi-structured interview so there is questions and you can under no wrong answers and you can digress if ever and if there's something I missed you think is important just don't hesitate to say so I'll be interviewing. Can you tell me have you've been using it at all the last few months?

D: Not too much in the past couple of months I think it's been more the main people and I think it's more the software glitch that we had in the last weeks yeah and but I think the way the system's been has it's been more or less self contained it so that's good because it shows that obviously then they don't need solve advanced technical support for it.

SN: Did you have did you use the joystick interface?

D: I did briefly to play around with it it was okay but I think I've gotten too accustomed to the previous one so it was all by don't think I had use it enough to adapt so

SN: Okay I was it for you to be part of this test period because, you've been actually part of a sort of design

D: It's been an interesting sort of process I mean we've seen lots of positive use from it and not your everyday -laughs-

SN: And did it influence your work was it was it demanding for you in a way - did you try to fix it?

D: Yes I think it was very autonomous so a lot of the building staff looked at trying to work out how to use it first which was positive and then if they couldn't they then looked at me which I think the only time that I really need additional support was just when they needed yourself so no there was nothing that they could have done I could have helped them with.

SN: Have you been talking it all to the other side from Baltimore House to this side over the system?

D: A couple times yes all right and I much prefer Baltimore house because you can see a lot more so it feels as if you're in control

SN: Yes, you can just scan the room also.

D: There is, sometimes it's more of a mystery because I'll talk from this side (the visitors side -SN) and I don't know if someone's there or not.

SN: How does this work out actually because that's a feature of the system that's it's actually open from the other side so you can you can actually always pan the camera and look around the room while not being observed by this side. So it's how does that work out does it make you feel in any way observed

D: No I quite often use it the same as if I'm talking to someone in the same building because I know that it's open on the other side I know I can just shout through as if I'm talking to Reagan at reception.

SN: Okay, that's good and what do you think that can be improved about how to present it to the visitor?

D: I think if it's possible, make it more lightweight, because it looks very clunky, Yes you could make the design more slim, like sleek.

SN: Yes do you have any suggestions how to design it for the future? The screen, can it be smaller or bigger?

D: How it is now is quite right because if it was any bigger it would be like a giant face that you will be quite intimidating. I know E thinks she has a big face

on it but it's not - it's not too large no um but I think if it was just more or less the same size but everything just a bit more sleek.

SN: And do you use me because you just suggested that you actually used the joystick

D: I tried it out, yeah.

SN: How did that go, was it clear what's the functionality was?

D: Most of it, and just a little bit and but I think it might have been just because I was used to using the dial it was just trying mmm

SN: Are there any other functionalities you use the system for, like you earlier described, talking to C at the other side?

D: No. I just use the receptionist function: if I want to know something quickly and I didn't just know I can talk to the system because I know it's always open so I know they hear me at the other end, not having to use the bell I

SN: Did you get used to using the system, did it become part of your daily routine?

D: It was very easy to just adapt to the system, so when it was switched on and running

SN: Okay and did you encounter any freeze frames or something like that when he goes all was a stable

D: Every time I'd seen it or when I used it, it seemed fine I don't know if the guys (the colleagues -SN) are having difficulties but then they seem to be very on the ball when to correct initial when something wasn't quite right

SN: Can you describe your learning curve mastering the joystick was it was it immediately clear to you how it works

D: The movement was easy but it was the ringing of the bell that was a bit different.

SN: There was a glitch with the LED button.

D: When I was trying out the joystick (sometimes -SN) the red LED lamp lit up,

SN: The red LED button opens up the A / V connection.

D: OK, because I think that's what confuses a little because when I was pushing the LED to open it and it wasn't switching on so I cut the other ones. (the LED button responds a bit slow sometimes -SN)

SN: I had the same experience sometimes that are just it's really weird because they're actually buttons that are designed to last a lifetime.

SN: The booting up of the system that's also clear to you?

D: I think it was there was probably a bit of a learning curve because it was I think when we got into the routine of first switching on PROTO and then Baltimore Houses end. At the start we were just calling E and she would turn her side on and then sometimes we would find this a bit of an issue like you know sometimes with like switch one on then forget it turn the other one on but then we when we got into the routine of right we'll do PROTO first then we'll do Baltimore house then, it just generally works. It would just be more practical if it could be started in say 30 seconds than 3 minutes.

SN: Where can we improve the system as a system, so not the external appearance but how its functions things you would change?

D: I kind of feel that if you could turn on either system so as long as they were both active that they can kind of automatically work, so it does not matter if you first turn on PROTO then Baltimore.

SN: And the functionality? Because our idea is to integrate all functionalities, like the opening of the doors for instance but also scanning mail.

D: I would appreciate it if there was like an electronic box where you could deliver mail, because obviously some tenants would be worried about security. I there was a way to drop parcels safely in the reception area, that would be great..

SN: The design of the controller, what would you suggest? What in your opinion could be added or could be improved and did you like the ball-shaped interface or the joystick controller?

D: I think the ball one I got used to but I haven't used the joystick enough to kind of make much of a like a solid conclusion but I like that everything was kind of like neat that it was an all-in-one system

SN: It's my mission to make interaction with systems simple brother simpler.

Telepresence receptionist second series of interviews

May 20, 2019

E: not tech savvy, regular user

## INTRODUCTION

SN: You've been working now for more than 5 months do you use it regularly

E: I use is more than I thought I would.

SN: And in what kind of circumstances you

E: I pop it in for short spells

SN: You never use it the whole day

E: Just when I have to cover for next door.

SN: In the beginning when you used it was actually kind of quiet, still but now it's really busy.

E: It's more in the beginning (the building is in use for 7 months -SN) the building was managed a bit on its own.

E: And now what and what do you think of it after been using it for leave me using it for more than five months

E: I think it's a good start. Well you know she first attempt, It's the first machine and I'm sure they get more advanced.

SN: This has been a collaborative project.

E: It's a good start.

SN: We'll be making a new, more bespoke version, because this one is made of off-the-shelf parts.

E: It depends on the size of your desk: mine is quite small.

SN: Does influence the other work that you do, so is it a distraction for you?

E: It's a little bit tricky sometimes when that's on (the telepresence receptionist -SN) and I've got it's just a matter of time management of who do I see to first.

SN: And do you have used the button that says 'bear with us'.

E: I've never seen it working from that side I've only really seen it from my side.

SN: But do you use that functionality because that's what's it's for when you're when you're busy on this side: just to press the ball.

E: (confusion with E -SN) That's what the (LED -SN) light is for: I can see it's on at the other side. I want to know whether or not it's definitely on (and people can hear her -SN)

SN: And the use of the wooden ball, now you're using it again, how does it feel for you?

E: I prefer that but it's not really advanced technology (laughs).

SN: But you prefer it over the other one?

E: Yes, it's more easy.

SN: And how do you feel about talking to the other side?

E: It does not bother me.

SN: I remember in the first interview you said it was sometimes a little bit awkward

E: Personally, I don't mind doing it but I think sometimes at the other they don't know whether or not to press that bell, a little bit like 'are they allowed to'. Is it private equipment? It could be a little bit more user-friendly.

SN: The bell is supposed to be that, so that ties into the next question what do you think that can be improved about the way system is presented, not functionality but how it comes across.



E: I think it's alright.

SN: It's big on this side so we're aiming to make it more slender

E: so a really slender design yeah because my desk is quite narrow.

SN: Next door the idea is to make it more or less look like it is life-size .

E: I don't like it to see my full body on a screen.

SN: You've been using the joystick, how did that go?

E: What do you mean, compared to the ball? I prefer the ball, it's less effort.

SN: Did it get part of your daily routine?

E: Yes, if you can use it, you use it.

SN: Other users say it reminds me of my gaming years. Can you describe the learning process when the joystick was implemented because it has a little bit of a different functionality.

E: Its troubles.

SN: "What do you mean?"

E: I think it's (the ball shaped interface -SN) just quick, you want the system to be quick you know. Also the starting up of the system, you first press it on that side (start the system by pressing the on/off button of the computer -SN) and then on this side, you have to ring each other, that's annoying sometimes.

SN: The LED button that indicates whether or not you're live or not how did that workout for you was it

E: The concept was good but it did not function always well. I was upside down once (software glitch -SN) and yes one time I could hear them and they could not hear me.

SN: How can we improve the system, are there functionalities that you like to see added to it?

E: When people come next door from the car park, I haven't got a clue. Sometimes they give false information.

SN: Now so it would be good to implement all the systems also the door opening system and an extra camera and screen at the car park.

E: That would be good.

SN: I have the idea that it would be practical to have an editor to edit the welcoming sign on the screen there so when there's something like a presentation going on you can announce it on the screen.

E: That would be good, more dual use: when I'm not using it as a virtual receptionist it could be like an information welcoming screen

SN: The controller: do you have any suggestions for the design of the controller because you think it's rather clunky and the wooden ball you would rather have a metal or.

E: I don't know what your plan is, do you want to make it wireless, because there's so many wires now.

SN: The idea is that there's only one wire or maybe it's even wireless and make it part of the stand (of the controlling touch screen SN-) it's also an option

E: I think it's alright now as long as there are not so many wires.

SN: And they're not all over your desk. Do have other suggestions like what we call user scenarios? Do you also use it for just to talk to C?

E: Not really. Talk to C sometimes, yes.

